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HAND-BOOK OF INDIAN AGRICULTURE.

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HAND-BOOK

OF

Indian Agriculture.

BY

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"Discoveries made in the cultivation of the earth are not merely for the time and country in which they are developed, but they may be considered as extending to future ages, and as ultimately tending to benefit the whole race, as affording subsistence for generations to come, as multiplying life, and not only multiplying life, but likewise providing for its enjoyment."—*Sir Humphrey Davy.*

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PREFACE.

—:-o-:—

The publication of the Sibpur Lectures in the form of a Hand-book was found necessary owing to the want of a text-book on the whole subject of Indian agriculture suitable for the use of advanced students. It is not possible to learn agriculture from a text-book, apart from a farm, and to learn the subject in a systematic manner, a museum and a laboratory, are also necessary. Even one passing out of an agricultural college which is equipped with a farm, laboratory and museum, and possessing a thorough knowledge of a text-book, must be prepared to buy his experience, either by apprenticeship in another person's farm, or by losing money on his own, for a year or two, before he can expect to acquire confidence in himself, his crops and his methods. Book-knowledge and College-education must be supplemented by detailed experience in that particular department of agriculture which one chooses to take up, in any particular locality, before one can expect to be a successful farmer. A book, however, is a valuable aid to the student and also to the man engaged in planting or farming.

The Hand-book of Indian Agriculture pretends to little originality. Facts which now lie scattered in hundreds of Reports, Notes, Monographs, Ledgers and Journals, have been brought together here in one volume and treated in a systematic manner. But even

as a compilation the author hopes, that it will prove a useful companion to planters and students of agriculture generally.

CIVIL ENGINEERING COLLEGE,
SIBPUR,
The 11th August, 1901.

N. G. MUKERJI.

SUMMARY.

——oo——

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INTRODUCTION

THE inauguration of the Agricultural Lectureship in connection with the Sibpur Civil Engineering College is one of the outcomes of the deliberations of the Famine Commission that was sent out to India at the instance of the British Parliament in 1878. The Famine Commission submitted their Report in 1880, and for the last twenty years the recommendations of this Commission have been kept steadily in view by Government and given effect to one after another. Canals and railways, the most important measures of protection against famine, have been extended since then with great rapidity. The systems of land administration and police administration have been greatly improved, chiefly with a view to give security of possession to cultivators, and to obtain correct statistics and prompt information regarding agricultural conditions and agricultural depressions. Finally, by the institution of agricultural experiments and agricultural education, foundation has been laid of ascertaining agricultural facts with a view to increasing and improving the produce of land, and diffusing agricultural knowledge among the cultivating classes.

2. Bengal, in fact, has been the last to take up the question of agricultural education. There is a well organised College of Agriculture in Madras. In the Bombay Presidency, agriculture is taught at the Poona College of Science, which is mainly an Engineering College. The Poona plan is being followed in Bengal. In the N.-W. P. there is a School of Agriculture at Cawnpur, and in the Central Provinces, at Nagpur. Agricultural primers have been in use in Bengal as in the other Provinces, though hitherto we have had no means of training village school masters in agriculture.

3. So satisfactory has been the result of agricultural education in Madras, where it has been the longest established, that a Committee appointed by Government to report on the working of the Agricultural Department and the Agricultural College of Madras, attached the highest importance to the Agricultural education imparted in the College and the Schools, and they devoted more than half their report to this subject.

4. It is often said, that the native agricultural practices are the best for India and that they are not capable of improvement. I was surprised to find during my tour of 1898 that the native agricultural practices of the Madras Presidency are far ahead of those of Bengal and the North-Western Provinces of India. If agricultural education has been found beneficial in the Madras Presidency, where the existing system of agriculture is really superior, how much more beneficial will it be for Bengal, which is so backward! We have not only to benefit from our knowledge of Western science and Western practices, but we have also to learn the superior practices followed by the non-Aryan races of the South. Indeed, Indian Agriculture has been actually vastly improved by our contact with the West. European planters have been the means of introducing important innovations. In the most out-of-the-way places of India we find European planters carrying on agricultural experiments and improvements imperceptibly and noiselessly. We find them growing the most delicate English vegetables even during the hot weather by cultivating them in trenches. Some of our commonest articles of food and fodder have been thus introduced by Europeans. Maize, oats, potatoes, tobacco, cabbages, beet, papya, the superior varieties of plantains, guinea grass, are all exotics. Indeed, there are few English cereals, root-crops, vegetables and fruits that have not been introduced with success into India, and European farm implements are in common use in some plantations. It is difficult to think of any agricultural experiments

that have not been already tried, successfully or unsuccessfully, by European planters. Even the steam-plough, which is still considered an expensive luxury in Europe, has been tried by two planters within my own knowledge.

5. The aim of this book will be to look into all agricultural problems, as much as possible, from the point of view of famine, that is, with reference to the masses of the people, and not to the Epicurean or the rich, who seek delicate flavour rather than quantity and nourishment. It will consider how soils can be made to yield more than they do, how irrigation can be made possible for the poor raiyat, how to extend the cultivation of drought resisting crops, how to preserve, without damage, food and fodder, the excess production of one year, for years of scarcity, how to organise measures of protection against famine. If any one expects to learn from these pages the best methods of breeding peacocks, turkeys and guinea fowls, of growing artichokes and asparagus and peaches, he will be sadly disappointed. These pages will be devoted almost entirely to the consideration of the food and other necessaries of life for the masses, or what can become food &c. for the masses. They will discuss only such appliances and machinery as can be used by the poor raiyat individually or collectively. They will analyse only such manures as may be placed within easy reach of the raiyat. They will explain the means of getting rid of and of avoiding pests and parasites that are so destructive to ordinary crops. In one word, this Hand-book hopes to be able to be a guide, philosopher, and friend, to the actual cultivator, and be the means of ameliorating his condition. Seventy per cent. of the people of India live directly by farming, and it is of paramount importance to study those questions which affect so large a proportion of the population of India. In no other country in the world does such a large proportion of the population depend on agriculture. In England only 7·5 per cent. of the population live by agriculture.

6. I do not mean to say that the Agricultural condition of India is in a specially depressed condition, as it is in some countries in Europe. Barring occasional famines, local or general, which has been the order of the day in India at all times, the agricultural population of India may be regarded as being in a prosperous condition. The area under cultivation is steadily increasing; exports of food grains, which represent surplus stocks, have been also increasing notwithstanding increase of population, and the rental and revenue from land have grown. There is no such thing in India as lands getting out of cultivation, and farmers getting ruined and emigrating to foreign countries in quest of a living. Emigration in India is still a forced project. In spite of his debts, which are a hereditary thing with the Indian raiyat, we do not find many cultivators alienating their holdings and going in for other trades. Many crafts and trades have suffered of late years, but not agriculture. The agricultural produce of other lands has not been able to compete with India's own products, and she has always more and more to spare for the needs of other countries. The late famine in Bengal went to show that the resources of the masses had increased of late years. The failure of crops all over India since 1896 has been unprecedented, and, if this had taken place 20 years or even ten years earlier, the havoc among the agricultural population would have been terrible. But the resources of the country have been developing steadily for over half a century. It is a significant fact that, during the 61 years ending the 31st March 1896, India imported foreign merchandise to the value of Rs. 1931,00,00,000, while during the same period the value of her exports amounted to as much as Rs. 3064,00,00 000. Her exports therefore exceeded her imports by Rs. 1133,00,00,000. Of course, the whole of this does not represent so much into the pockets of the Indian peasantry. But that Indians, and especially Indian cultivators, have materially benefited by this excess

of export of indigenous produce can be inferred from the fact that, during the same 61 years, the balance of import of gold over export was of the value of Rs. 146,68,00,000. Of this only Rs. 2,44,40,000 worth of gold was used during the 61 years in the mint for coinage, and the balance of gold to the value of Rs. 144,00,00,000 must have been absorbed by the people, chiefly in making articles of jewellery, which are pawned largely in famine times. Poor as the Indian raiyat has always been, his poverty is not so intense now as it used to be, and he can afford to spend money on little luxuries which his forefathers never dreamt of enjoying. The ambition of the landless labourer is to buy land and to become an agriculturist. The man who earns Rs. 10 or Rs. 12 a month in a Calcutta mill also looks forward to saving enough of money for buying land and cattle and settling down as an agriculturist. Surely agriculture pays, and it is not in that depressed condition in which it happens to be in some countries in Europe.

7. Let me not be misunderstood. I do not mean agriculture will pay a 'gentleman.' It is only by dint of hard labour and frugality that the Indian cultivator makes agriculture to pay him. If a gentleman were to employ labourers and go in for ordinary farming, he will find these labourers (so industrious when working for themselves) sleeping over his work and accomplishing very little when pretending to be doing work actually in his presence. He can never compete with the actual cultivators in ordinary agriculture, as by their frugality and industry they will be able to get their outturn at a smaller cost and thus undersell him. He may succeed with a new crop, but only for a time. When the cultivator finds out how he grows it, and where he sells it, he (the cultivator) will grow it at a smaller cost and put it on the market at a smaller price. I have taught scientific methods of sericulture during 11 years to a large number of persons, among whom were a number of actual

cocoon-rearers. It is these latter alone who are carrying out the new methods with profit, while all the educated men who have gone in for it have lost money.

8. Capitalists and educated men can derive profit from agricultural pursuit by acting as middlemen,—finding land, seed, manure and appliances for cultivators, and using their labour and their cattle and sharing with them the profits. Cultivation by partnership is indeed a well-recognised system in Bengal, and, if trained agriculturists go in for it largely, this system may prove to be of the highest benefit in introducing superior staples and superior methods of cultivation. One has, say, 500 bighas of land. He gets some cultivators of the neighbourhood to go in partnership with him and to give him half the produce. He gives them seed, well-selected and of superior kinds; he finds them superior appliances for irrigation, hoeing, thrashing and winnowing; he buys for them manures, and he takes half the crop for himself. He knows how to store his crop secure against insects, and he sells it for seed again at twice the price at which he would have sold his crop at harvest time. This would be an improvement over the ordinary system of cultivation by partnership.

9. Then by the employment of capital one can compete successfully with cultivators in such agricultural, or rather industrial pursuits, as require large outlay at the start. Two graduates of Saidapet College are making large profits by starting dairies. The manufacture of cheese, butter and *ghi*, with appliances that cannot be ordinarily purchased by cultivators, would prove remunerative to a man with a capital. Fruitfarming also would probably pay well, if the fruits could be preserved by dessication or crystallization. Fruits and vegetables can be preserved by a rapid process of dessication. This is an industry which, properly developed, may have an important future before it. The abundance of one year can be preserved from rotting for consumption in another year.

10. But some of the students of the agricultural classes will

have to do with agriculture and agriculturists in the capacity of Revenue Officers or District Engineers. The knowledge of agriculture is of great value for Revenue Officers and District Engineers. When the Director of the Agricultural Department, or the Reporter of Economic Products, or any expert officer of Government, seeks any information of an agricultural character, or any samples, he usually refers to District Officers for such information or samples. The District Officers consult their Deputies or the District Engineers, and they (the District Officers) usually find out how ignorant their subordinate officers are regarding the circumstances and the wants of the cultivators. Revenue Officers and District Engineers with an agricultural training are likely to acquire some sympathy for the masses of the population who are employed in producing the staff of life, and whose interests these officers are now too apt to forget or to ignore. A mere literary and scientific training gives one little knowledge of the immediate surroundings in the midst of which one's lot is likely to be cast in actual life, and little aptitude in dealing with such surroundings in official capacity. The agricultural statistics which ought to be of great value in estimating the resources of the people in times of famine, being compiled by men who have very little practical acquaintance with land and its produce, and who, owing partly to the very education they have received, are accustomed to take so little interest in such questions, were found to be of little use during the late famine in Bengal. The famine programmes, annually prepared in anticipation of famine by District Engineers, were found wide of the mark, and they were in practice ignored. The district staffs may in future be manned by officers who have received not only a literary and scientific education, but who have been accustomed to see and handle the things with which they will be ordinarily surrounded in their practical life. Such officers will be able to draw up famine programmes in an intelligent manner after

ascertaining local conditions, and enquiring of the cultivators themselves if they had any works to suggest which might protect against failure certain tracts. In certain localities, I know of, cultivators have been accustomed to cut across roads and bunds, and admit water into their field, for protection of their crops; they have been fruitlessly applying for years to the District Engineer for a sluice gate here, a channel there; and for permission to open a lock-gate a little earlier or a little later than usual, and so on. Having an eye to the protection of crops officers with rural training will be able to shape their famine programme and their annual programme in the interest of cultivators. How many District Engineers there are who utterly ignore the interest of the cultivator, and who simply look upon questions from a road or a bund point of view only. As Deputy Collectors in charge of Government estates officers with agricultural training will recognise the position of Government as a model zemindar for the *khas mahal* raiyats, and they will know how to utilise the "Khas Mahal Improvement Fund" to the best advantage. Government can depend upon their initiating the "khas mahal" tenants under their charge to at least one permanent improvement, for which they will be always grateful to Government and to the officers concerned, specially in times of famine. If, for instance, they can induce the "khas mahal" tenants under their charge to grow tapioca roots, and teach them to use the roots for food and to extract flour out of them, they will have done some permanent good and they will have saved those tenants perhaps for all times from the jaws of famine. As managers of Court of Wards Estates they will also have ample opportunities of utilising the allotment annually made for agricultural improvements by introducing well-thought out reforms. They will find in most places it is some practicable method of irrigation that the raiyat needs, and, if they can give him a canal here, a well there, a windmill somewhere else, and teach him how to lift water from small depths and

great depths with fairly cheap appliances, the outlay they will incur on account of the estate they may happen to manage, may protect a certain precarious tract for all time to come from drought and failure of crops.

11. And the educating influence of such innovations, even on the Indian raiyat, who is proverbially conservative, though slow, will be lasting. For the raiyat, though conservative is only obliged to be so on account of his poverty. He cannot afford to lose money by launching out on mere speculations. But, if the benefits of some practicable methods are demonstrated,—persistently demonstrated—before his eyes, even he will be induced to change his old ways. Have not the cultivators taken to growing potatoes and tobacco, and using the Behia mill for crushing sugarcane, and the microscope for selecting silkworm grain? You have to treat the raiyat with a little patience and you must have confidence in your own methods.

12. But the question of famine in India is mainly a question of irrigation, and, to manage irrigation properly, one must have a fairly solid knowledge of Engineering and of Agricultural Sciences, and looked at in this light the addition of an agricultural course to the Engineering, is a very judicious scheme. It has been observed that the productive power of soil diminishes after a number of years where canal water is used too freely for the purpose of irrigation, and that localities too freely irrigated with canal water become malarious. The question of well-irrigation is being seriously discussed as probably fraught with greater advantage, and along with this must be considered suitable implements for lifting water from various depths.

13. On the whole, however, there cannot be the slightest doubt that canals have proved the best protection against famine. I will quote a few figures from the reports of the Famine Year 1896-97, to prove that the construction of canals should be undertaken, wherever possible, by way of relief work, at any rate, in famine times.

14. In Bengal the total capital outlay on canals up to the close of 1896-97 had reached a total of Rs.7,61,23,817. The total length of canals in operation was 916 miles, including 738 miles used for irrigation, the rest being used for navigation only. There were also 2,605 miles of canal distributaries. These were capable of irrigating 1,572,005 acres. The receipts for 1896-97 amounts to Rs. 25,63,047 and the working expenses to Rs. 19,37,142, the net revenue being Rs.6,25,905 against Rs. 2,45,646 and Rs. 1,38,135 in the two preceding years. The areas actually irrigated from these canals in 1896-97 and the two previous years were respectively 805,387 acres, 579,933 acres, and 509,811 acres. The average outturn of paddy per acre from canal irrigated areas may be put down at 24 maunds representing 16 maunds of rice. The outturn of grain from the 805,387 acres served by canal water may be put down at 12,000,000 maunds. The annual consumption of grain per individual adult being put down at 6 maunds, the number of adult units directly saved from starvation by canal irrigation in Bengal during the recent famine may be calculated at two millions.

15. The figures for the N.-W. P., the Punjab, Sind, Bombay and Madras are equally or still more satisfactory. In the Punjab the whole of the capital outlay of 841 lakhs of rupees has been more than recovered, the net revenue up to the end of 1896-97, amounting to 866 lakhs of rupees, or taking the interest charge of 556 lakhs of rupees into account, the State has already recovered 310 lakhs out of the 841 lakhs spent in irrigation works in the Punjab. In 1896-97, the gross revenue exceeded 109 lakhs, while the working expenses were below 31 lakhs, leaving a net profit of about 78½ lakhs to the state, which is equivalent to 9.34 per cent. on the capital invested. The area irrigated in the Punjab in that famine year was 4,621,000 acres, *viz.*, one fifth of the total cultivated area of the province. Of this 1,441,000 acres were under wheat (which alone must have saved between three and four million

persons from starvation). The total quantity of food crops of all kinds raised by canal water in the Punjab in 1896-97 sufficed to feed 6¼ millions of people or a quarter of the entire population of that province. But the area actually irrigated does not represent the whole that is possible to irrigate and grow food grains on. The capital outlay on canal works, though enormous, represents but a small fraction of the benefit rendered to agriculture through their means. The value of the crops raised by canal irrigation in the Punjab in 1896-97 alone was estimated at 1,508 lakhs of rupees, *viz.*, nearly twice the amount of the whole capital outlay incurred from the commencement; the value per acre being estimated at Rs. 33, while the water rate levied was Rs. 3-4.

16. A knowledge of agricultural science will enable one to avoid bringing about a deterioration of soil by canal irrigation. Irrigation water judiciously used adds to the fertility of the soil, while injudiciously and lavishly used it can wash the good gradually out of the soil and render the locality unhealthy at the same time. The cultivator will take 9″ of water if he can get it, though 2″ to 6″ according to the season of the year will do him more good than 9″, leaving the fertility of the soil in tact, and the locality free from malaria. It is in the direction of extension of canalworks that agricultural engineers can be most usefully employed.

17. It is somewhat unfortunate, however, that in this as in every other country, agricultural education is being taken advantage of almost exclusively by persons who are not directly interested in agriculture. Neither the farm labourer, nor the farmer, nor the landed proprietor, cares, as a rule, for agricultural education. Agricultural Colleges and Schools in almost every country are crammed either by place-seekers or by townbred men who fancy they can make their fortune by scientific farming or by cattle-ranching. In other countries such men do occasionally turn out successful farmers or colonists. But in India the caste system has ingrained and

stamped in different classes different abilities and disabilities in such an indelible manner, that the priestly and writer castes who generally go in for high education are *ab initio* unfit subjects for agricultural training. Their instincts, their habits of body and of mind, are not suitable for agricultural occupation. They are eminently fitted for other paths of life, but not for success in agricultural pursuits. It is doubly important therefore for India that the right classes of people should be encouraged to receive agricultural education, that the benefit derived by them may easily filter down to their fellow-caste men in rural tracts. To expect the benefits of agricultural education to filter down to rural tracts from the prospective gardens, farms and plantations that the Bengali or the Mahratta 'gentleman' may establish after receiving agricultural education of a high order, is I am afraid, a deluded hope. Vernacular education, on the other hand, has spread so far in rural tracts in Bengal, that we can now find many actual cultivators who have passed the Middle Vernacular or even the Normal School Examinations. They are quite capable of receiving a systematic training in agriculture, and these are the men who will have influence among their fellow-castemen. In dealing with agricultural pupils of the cultivator class a great deal of patience, a great deal of sympathy, is at first needed. But when once a headway has been made among them, agricultural progress will come directly through their agency. It is therefore of great importance to induce, by the offer of suitable scholarships or otherwise, sons of *bona fide* cultivators who have passed the Middle Vernacular and Normal School Examinations, to come for special agricultural training to a central institution, and then go back to their respective villages. Such men will not feel disappointed if they cannot secure Government appointments. Training a hundred men of this sort by the judicious allotment of a hundred scholarships, will have far more effect in ameliorating the agri-

cultural condition of this Province than training a dozen University graduates annually who will probably give up all connection with agriculture in disgust if they fail to secure Government appointments. It is by the spread of agricultural education mainly and not by reduction of revenue demand or opening of agricultural banks that the question of famine must be met. There is no occasion for the *raiyat* to starve when there is a shorter rainfall, but the *raiyat* does not know how he can help himself. He must be taught. So while a class has been established in Bengal for higher training in agriculture given to a few University graduates and engineers or surveyors with the object of employing them as Government officers in certain special capacities in which agricultural knowledge is needed, it must not be forgot that the more important scheme, of giving a thoroughly practical agricultural training in a properly equipped farm, to the actual cultivator, is yet to follow.

PART I.

SOILS.

CHAPTER I.

GEOLOGICAL STRATA.

IF we make borings into the earth or study railway cuttings by hill sides, we find the earth and rocks exposed are of different character and consistency, and we notice, as a rule, well-marked stratifications both in the loose earth and the hard rocks so exposed. The deepest mine is only about ½ a mile in depth, and so we can study the soils and rocks only of the outer crust of the earth. As the rocks, however, do not always occur in horizontal layers, and as the crust of the earth has evidently undergone violent contortions, we are able actually to study rocks situated down to a depth of about 20 miles, on the very surface of the earth. In other words, there are rocks on the surface of the earth which would have been buried 20 miles deep had not violent eruptions brought them up to the surface. The evidences for such eruptions are numerous. We find the temperature of the crust of the earth increases by about 1°F. for every 56ft. of depth. The deeper we go down in a mine the warmer it is, and we can only imagine how hot it is 20 miles below the surface of the earth. It is over 2000° F. a temperature at which all minerals and rocks must be in a fluid and disturbed condition. We have further evidence of this internal heat in hot-springs, earthquakes and vol-

canoes. Earthquakes and volcanic eruptions were very much more violent in past ages than they are now. Take, for instance, the Deccan trap formation, 200,000 square miles in area and as much as 6000ft. deep in some places. The volcanic outburst that resulted in this deposit must have been most fearful. But all over the earth's crust we have evidence of contortions and dislocations of the strata that form the outer crust of the earth, which point to very great heat acting from within the bowels of the earth. This heat gradually becoming less, in other words, the earth getting cooler and cooler, the disturbances on the earth's surface have also become less and less. At one time the heat and the disturbances in the shape of earthquakes and dislocations were so great that no plant or animal could have lived on the surface of the earth. Gradually the surface getting cooler and quieter, plant and animal lives made their appearance. But thousands and perhaps millions of years elapsed before the surface of the earth became fit for human habitation. It is supposed that our planet was originally a portion of the sun, and that it was spitted out by the sun by a violent centrifugal action. This nebulous or fluid mass of burning and revolving matter has been gradually getting cooler and cooler and solidifying from the surface downwards. The composition of the whole of the solid crust of the earth can be studied and even of a portion of the fluid 'magma,' as it is called, lying underneath the crust, as volcanic action has exposed to the surface not only the solid strata but also the liquid magma below.

19. Geologists have found out in the midst of all the contortions and dislocations to which the outer crust of the earth has been subjected for ages past, that the strata forming the crust occur in a certain definite order all over the earth's surface. In England these strata occur in beautiful regularity from S. E. to N. W., the newer formations at the S. E. and the older formations at the N. W. In other countries although

these strata do not occur in such regular succession exposed to the surface, the same order can be traced all over the surface of the earth.

20. If we study the character of the rocks so exposed in succession, either vertically in cuttings or horizontally as we pass from field to field, and district to district, we will find two classes of rocks, stratified and unstratified. Unstratified rocks are igneous in origin, *i.e.*, thrown up from the burning bowels of the earth. The stratified rocks have been formed by fluvial lacustrine or marine actions, sedimentation, stratification under pressure and infiltration of substances acting as mortar. Heat played an important part in the formation of some sedimentary rocks. These are called metamorphic rocks or schists.

21. Studying the geological strata from below upwards, we find the following order prevailing in the deposition of these strata :—

The first, that is, the lowermost stratum, may be called the *Lower Magma*. These are basic rocks rich in earthy bases and oxides of iron. Volcanic action has exposed this deep liquid layer to the surface of the earth in the form of Basalt, Dolerite and Zeolite. Greenstones and basalts generally are called *trap* rocks as they occur in the form of steps on hill sides. The solidification of the Lower Magma taking place after volcanic eruption on the surface of the earth, the Lower Magma occur chiefly as volcanic rocks. These volcanic eruptions did not take place in the earliest geological ages, but later on. The first eruptions took place from the Upper Magma, *i.e.*, the lighter siliceous or acidic layers. The basalts are found chiefly in the meso-zoic and neozoic formations of which we will speak later on. All over the plains of Deccan occur trap rocks, usually in horizontal layers of 6 to 90 feet, each layer being a separate lava deposit evidencing a succession of volcanic eruptions. The total depth of these successive deposits of trap reaches in some

places to 5,000 or 6,000 feet, and the total area covered by these trap rocks is about 200,000 square miles. The minerals found in trap rocks are Quartz, Chalcedony, Agate, Jasper, Limestone, and Zeolites. Soils formed from decomposition of trap rocks are naturally very fertile, being rich in silicæ, alumina, iron, lime, magnesia, potash, phosphates and soda. The celebrated Black cotton soil or *Regur* of Southern and Central India was formed out of trap rocks probably in shallow fresh water lakes. The Volcanic eruptions which have given rise to the lava and tuff formations of Southern India, took place in the cretacious period and the absence of volcanic craters in these regions, shows, that the eruptions were fissure-eruptions giving rise to plateaux instead of hills of Basalt.

2nd.—The Upper Magma resting on the Lower Magma is lighter and is mainly composed of Silica. This stratum is therefore called Siliceous or Acidic Magma. It is mainly Plutonic, *i. e.*, solidified by slow cooling under pressure, and occurring, in consequence, in the form of coarse grained crystals compacted together in the form of granite. Acidic rocks occasionally occur as Volcanic rocks, *e. g.* Trachyte, Obsidian and Pumice. The presence of Plutonic granite or Volcanic Trachyte, Obsidian and Pumice, is an indication of the earliest geological formation. It usually intrudes into gneiss and it is sometimes difficult to distinguish between intruded dykes or veins of granite and metamorphic schists owing to gneissose structure of some of these granite veins. Veins and dykes of granite occur throughout the vast metamorphic or gneissose rocks of India, all along the Himalayas, in the Arravali hills, and mainly in the Deccan. Granite consists of Quartz, Mica and Felspar, in varying proportions. Quartz and Mica are not of much value as fertilizers, but Felspar is. Soils formed out of granite are therefore less fertile than those formed out of basalt.

The Acidic rocks contain 60 to 75 % of SiO_2, the basic

rocks less than 50 %. The acidic rocks are light, and more infusible, while the basic rocks are very heavy and of fine texture and they are not so infusible. The principal acidic rocks are :—*Granite*, *Felsite*, *Obsidian*, *Pumice*, *Syenite*, *Trachyte*, and *Porphyrite*. The principal basic rocks are *Basalt*, *Dolerite*, *Diorite*, and *Gabbro* (containing Diallage and Labradorite.)

3rd.—The Azoic or metamorphic rocks.—These consist of gneiss, mica-schist and clay-slate, formed by the joint action of sedimentation in water and compaction by heat. They are called Azoic because no trace of life has been discovered in them. There are three distinct systems of Azoic rocks which from above downwards may be called the Vindhyan, the Sub-metamorphic and the Metamorphic. The Vindhyan system consists of sandstones, limestones, shale and iron pyrites, and the dendritic markings of earthy manganese oxide which may be easily mistaken for fossil plants are characteristic of this system. The Sub-metamorphic system consists of Quartzite, sandstone, slate, shale and limestone of more igneous or crystalline appearance. The older and still more crystalline rock which abounds in Southern India is called gneiss. More than half the Peninsular area is on gneiss. From Cape Comorin to Colgong on the Ganges, a distance of 1400 miles with a mean width of 350 miles, or an area of nearly 500,000 square miles, is composed of gneiss or soils formed mainly out of gneiss. Patches of newer strata occur here and there on the gneiss. The Bundelkhand gneiss is the oldest of all. Gneiss also occurs in the Himalayas, in the Chutia Nagpur Division and in Assam. It is composed of Quartz, Felspar, Hornblende, Chlorite, and Mica, all or only two of which minerals may be present. Lead, silver, garnet, corundum, and diamond are occasionally found in Azoic rocks. The lead-ore or Galena of Bhagalpur is argentiferous. Lead-ores occur in Chutia Nagpur also. Diamond occurs chiefly

in the lower Vindhyan rocks. The greatest depth of the Azoic system is 26,000 feet. The soils are somewhat better than granitic soils, but mica schists which contain no felspar, but only quartz and mica, are poor. Quite recently Apatite has been discovered in the mica mines of Hazaribagh,—a fact which is of considerable agricultural importance.

4th.—Above the Vindhyan system which represents a transition between the true metamorphic gneiss and the true sedimentary rocks of the Lower Silurian system which are marked with ripples, come the *Palæozoic rocks.* The Palæozoic period is characterised by the first appearance of life, though the remains of very few animals have been discovered in the older of these rocks. A few zoophytes and trilobites and graptolites and some shells called Oldhamia are the fossil-remains found in them. The greatest depth of the Lower Silurian rocks, as these older rocks are called, is about 30,000 feet and of the Upper Silurians about 108,000 feet. The *Lower Silurian* rocks consist of shales, sandstones, limestones, and conglomerates. This system is scarcely represented in India. Lower Silurian beds are found overlying the Himalayan gneiss. The *Upper Silurian* system consists of the *Old-red-sandstone* (90,000 feet), the *Carboniferous rocks* (15,000 feet) and the *Permian group*, (3,000 feet) or the *New-red-sandstone.* Of these the Carboniferous rocks are chiefly represented in India. These consist of encrinitic limestones, shallow beds of sandstone, and coal measures. The coal measures of Bengal are of great importance, and coal in them being associated with iron and limestone, their importance as centres of manufacture is evident. Coal exists in an igneous or crystalline form called graphite in the older metamorphic formations, and it exists as coal in the later tertiary formations also, and in the recent formations as peat. The coal of Bengal is characterised by the usual fossils of the carboniferous systems *viz.*, lepidodendron and calamite. The Ranigunj coal fields

embrace an area of about 500 square miles, the Barrakar coal fields about 220 square miles and the Jheria coal fields about 200 square miles. The depth of some of the Ranigunj coal seams is 70 to 80 ft. The Bengal carboniferous system comes under what is called the *Gondwana sytsem*. Palæozoic animals were mostly marine. The fishes of this period were characterised by bone armour-plates. The soils of this system are indifferent, better than granite soils, but poorer than basaltic and alluvial soils. Soils of the Old red sandstone where limestones abound are rich, but they are scarcely represented in India.

5th.—The Mesozoic epoch. Air-breathing animals which first made their appearance at the close of the Palæozoic epoch, appeared in abundance at the Mesozoic epoch. The lowest group of this epoch is called the *Triassic* group (about 2,300 feet in maximum thickness). The next higher is called the Oolitic (about 4,500 ft. in maximum thickness) and the topmost group is called the *Cretaceous* (maximum thickness, 11,000 feet). Fossil remains of Labyrinthodon reptiles have been discovered in the Damuda valley above the coal fields of the Panchet hills. These are characteristic of the Triassic period. They have been also discovered in the Central Provinces of India: but Triassic rocks occur chiefly in the north-western Himalayas, where they occur to the thickness of 1,000 to 2,000 feet. The Oolitic group of rocks is subdivided into (1) *Liassic,* (2) *Jurassic* and (3) *Oolitic proper.* Monstrous reptiles (Icthyosaurus, Plesiosaurus and Pterodactyle) were the prevailing animals of this period. The ammonite and belemnite of the Himalayas are Oolitic. The shales and limestones of the Himalayas are both Liassic and Ooltic. The Rajmahal hills which abound in fossil plants are Jurassic. The cretaceous system is not represented at all in Bengal, though portions of the Nizam's dominion and of the Bombay Presidency and also of Assam belong to this system.

6th.—The Neozoic epoch follows the palæozoic, and at

this epoch for the first time we come across remains of animals and plants allied to those of the present time. The trilobite of the Silurian period, the peculiar bony-armoured fish of the Red-sandstone, the large club-mosses and reeds of the carboniferous system, the huge reptiles of the Oolite, the Ammonites of the Lias and the chalk, give place to new forms of life. Only 3 to 4% of the Tertiary plants and animals of the earliest strata are modern ; about 18% of the plants and animals of the middle tertiary period are modern, and there is no distinct gap between the close of the tertiary period and the recent period. The lowest tertiary period is called *Eocene* when the existing forms of life are first seen. The middle period is called *Miocene*, and the uppermost tertiary period is called *Pliocene*. The nummulitic limestone formations of the Himalayas often attaining a height of 16,000 ft. are marine and Eocene. Mammals appeared first in the Miocene period, and the extensive fossil remains of the Siwalik range belong to this period. The Sivatherium deer is the characteristic fossil of this period. Gangetic crocodiles and land turtles of modern times also occurred, also a huge but extinct species of tortoise a shell of which can be seen in the Indian Museum. In the Pliocene period man first made his appearance, and agate knives have been discovered in the upper Godavery characteristic of this period. The greatest depth of the Tertiary group of rocks is 9,000 ft.

7th.—Between the Indus and the Brahmaputra there lies a vast alluvial plain which consists mainly of Miocene and Pliocene Tertiary deposits. These are the *Recent Formations*, the commencement of this period being co-eval with the first appearance of man. In Bengal, though some of the other systems are represented, as we have already indicated, we are mainly concerned with these alluvial post-tertiary and recent deposits. The post-tertiary *Glacial* or *Pleistocene* period is probably not represented in Bengal, except at the Himalayas down to a height of 3000 ft.

8th.—Laterite. The origin of laterite and its position in the geological system are subjects of some dispute. Laterite is porous argillaceous rock much impregnated with iron peroxide, some containing as much as 25 to 35% of iron. The iron exists chiefly as limonite or hydrated peroxide. The surface of laterite after exposure is covered with a brown or blackish brown crust of limonite, but the rock when freshly broken is mottled with tints of brown, red and yellow and a considerable proportion consists of white clay which contains no iron. The exposed surface is pitted with hollows and irregularities caused by washing away of softer portions. The rock has a scoreaceous and volcanic appearance, especially as it is associated usually with basalt and other igneous rocks. But it is now usually believed to be of detrital origin produced from other rocks, igneous and sedimentary. The high-level laterite of Central and Western India does not appear to be detrital in origin as the iron is not sandy. The low-level laterite of Bengal is mixed up with sand, quartz, pebbles, ferruginous sandy clay and gravel. The high-level laterite always caps the highest lava flow, which makes the subject of its origin so difficult to understand. Probably the laterite has been formed from the disintegrated tuffs and scoriæ, rearranged by the action of water. As laterite resists the disintegrating action of the atmosphere longer than any form of Basaltic rock, the high-level laterite still caps the basalt. The low-level laterite is probably the detritus of the high-level laterite. The action of rain and streams having carried away the lighter sand and clay, the heavy iron sand is left as laterite and to this may be due the concentration of the ferruginous element. The age of the low-level laterite is certainly post-tertiary, though that of the high-level laterite is uncertain, the origin of this laterite being uncertain.

9th.—Alluvial deposits and Blown sands.—Blown sand forms the soil of places close to the sea, and its deposit

is quite recent. Alluvial deposits will be dealt with in the next Chapter.

22. The strata of the crust of the earth from the top to the bottom or from the most recent to the oldest, may be graphically represented as below :—

- A. Neo-zoic
  - *Post-Tertiary*
    - Recent (1st).
    - Pleistocene (2nd).
  - *Tertiary*
    - Pliocene (3rd).
    - Miocene (4th).
    - Eocene (5th).
- B. Meso-zoic
  - Cretaceous (6th).
  - *Oolitic*
    - Oolitic proper (7th).
    - Jurassic (8th.)
    - Liassic (9th).
  - Triassic (10th).
- C. Palæozoic
  - *Upper Silurian*
    - Permian (11th).
    - Carboniferous (12th).
    - Old red sandstone (13th).
  - *Lower Silurian* (14th).
- D. A-zoic
  - *Vindhyan* (15th).
  - *Sub-metamorphic* (16th).
  - *Metamorphic*
    - Peninsular Gneiss (17th).
    - Bundelkhund Gneiss (18th).

23. The following summary of the geological strata as they particularly refer to India may be found useful :—

A. Neo-zoic.

1st. Recent.—Blown sands,* alluvium, fluvitile and marine, including deltas and lagoons, laterite and gravels. *Example,*—the united Delta of the Ganges and the Brahmaputra covering a space of 50,000 to 60,000 square miles and a depth of about 500 feet, and the whole of the Indo-Gangetic Basin. *General character,*—fine sands and clay with occasional pebbles or pebble-beds, beds of peat and remains of trees, but no trace of marine organism.

2nd. Pleistocene or Glacial period.—Erratic boulders and moraines in the Himalayas and Upper Punjab. Modern fauna.

3rd. Pliocene period.—Soft massive sandstone also clays and conglomerates, all fresh water, resting on the Nummulitic limestones. *Example,*—Siwalik-beds, full of fossil remains of animals, chiefly mammals allied to modern fauna ; also in Scind, the Punjab, the North-West-Provinces of India, also along a narrow strip of hills from the Jhelum to the Brahmaputra in the Sub-Himalayan region, 1,500 miles long and 12 to 15,000 feet in thickness.

4th. Miocene.—Marine sands, shales, clays with gypsum, sandstones and highly Fossiliferous bands of limestones. Uppermost beds are clays with Gypsum containing estuarine shells. This period is represented in Scind.

5th. Eocene.—Sandstones probably fresh water ; also marine limestones passing into sandstones and shales; Nummulitic limestones ; clays with Gypsum and Lignite abounding in marine fauna. Examples in Scind, the Punjab, Assam and Burmah.

B. Meso-zoic.

6th. Cretaceous or Chalky system 11,000 feet.—Here and there in the Himalayas especially in Assam, but all over the Indian Peninsula where it is covered over in the middle and east by the Deccan Basalt which is the volcanic lava of this period.

Oolitic 4,500 feet.

7th. Oolitic proper.—Ammonite and Bellemnite of the Himalayas in Himalayan shales and limestones.

8th. Jurassic.—Rajmehal hills (Characterised by Fossil plants) and Upper Panchet Series.

9th. Liassic.—Shales and Limestones of the Himalayas. Lower beds of the Rajmehal hills and the Lias of India belong to the Gondwana system.

10th. Triassic 2,300 feet.—Lower Panchet Series of the Damuda Valley showing remains of Labyrinthodon reptiles, also Valleys of the Central Provinces and of North-West Himalayas, where they attain to a thickness of 1,000 to 2,000 feet chiefly in North Kashmir and the Salt range of the Punjab. The Fossils are like those of the Alpine Trias. Belong to the Gondwana system.

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* It should be noted that (1) Clay, (2) Sand, (3) Gravel, (4) Peat, (5) Shell-marl and (6) Marine ooze of recent formation are analogous to (1) Shale, (2) Sandstone, (3) Conglomerate, (4) Coal, (5) Limestone and (6) Chalk of old geological formations. The older the sedimentary rocks the more compact they are. But their age is determined chiefly by fossils.

C. Palæozoic.

11th. Permian group or New Red Sandstone.—Thick beds of sandstones and shales of fluvitile origin. Belong to the Gondwana system. The Lower Series are the Talchir and Damuda rocks which correspond with the Permian rocks of Europe.
3,000 feet

12th. Carboniferous system.—Ranigunge, Barrakar and Jheria fields. Belong to the Gondwana system. *
15,000 feet.

13th. Old Red Sandstone.—Scarcely represented in India.
90,000 feet.

14th. Lower Silurian.—Shales, limestones, sandstones and conglomerates. Scarcely represented in India. Found on the top of Himalayan Gneiss.
30'000 feet.

D. Azoic.

15th. to 18th Archæan rocks.—Oldest known rocks of India are Gneiss underlying the ancient Palæozoic rocks. They belong to two periods. The Older or Bundelkhand Gneiss (18th) is covered unconformably by certain transition or Sub-metamorphic rocks (called also Vindhyan system of rocks) which (15th) as they approach the Younger Gneiss become altered (16th) and intersected by Granite intrusions. The Younger or Peninsular Gneiss (17th) is also unconformable to the Older Gneiss. In West-Himalayas both the Gneisses occur. The Upper Himalayan Gneiss (16th) is formed by the metamorphism of Older Palæozoic rocks. The Lower Himalayan Gneiss is truly Archæan.
26,000 feet.

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* *Gondwana system* :—The upper strata of the Palæozoic and the lower strata of the Mesozoic groups in India (*i.e.* from Jurassic down to Carboniferous rocks) are included under the Gondwana system. They have been probably deposited by rivers and are chiefly composed of sandstones and shales. Plant remains are common but not animal remains. Rajmehal hills, Damoda Valley, the Tributary Mehals of Orissa and Chhatishgarh, Chutia Nagpur and Upper Son Valley, the Satpura range at the Godavery basin, are the localities representing the Gondwana system.

CHAPTER II.

SURFACE GEOLOGY OF THE BENGAL DISTRICTS.

MOST districts of Bengal and Bihar are alluvial. This alluvial plain is a portion of the Indo-Gangetic basin which includes about 300,000 square miles, or $\frac{1}{4}$th of the whole of British India. It is the richest and most populous tract of land, consisting of clay, more or less sandy. Peat, gravels, conglomerate and pure sand occur at intervals. Pistolitic concretions of hydrated iron-peroxide abound in certain regions. In Dinajpur the nodules of iron-peroxide are as big as pigeons' eggs; but usually they are of the size of peas or even smaller. The alluvium is classified into Old and New. The older alluvium is at a higher level,—in the Burdwan Division, in some places, over 100 feet above the sea-level. The newer alluvium occurs near channels of rivers. The Delta of the Ganges and the Brahmaputra is also new alluvium. No marine fossils have been discovered in this alluvium, though in Calcutta a boring down to a depth of 481 feet was made. This boring clearly demonstrated that the surface of the land in the neighbourhood of Calcutta has sunk to a depth of at least 481 feet within the recent geological age. Fresh water shells, pebbles and bits of wood that must have occurred at one time at the surface were brought out by this boring. The greater portion of the Ganges alluvium is Old alluvium containing beds of *kankar* or carbonate of lime nodules, and of pistolitic concretions of hydrated iron peroxide. On the western edge of the delta of

Bengal there is a large area of this older alluvium, where the surface is somewhat undulating evidently in consequence of denudation. This tract which is continuous with the newer alluvium of Eastern Bengal, comprises the greater portion of the country to the westward of the Bhagirathi and the Hooghly and owes its comparative elevation to the deposits from the Mourakshi, Ajay and Damodar, brought down from the Rajmehal series of hills *i.e.*, the range of hills in Bengal extending north and south from the Ganges to the neighbourhood of Suri in Bengal and, unlike the other members of the Gondwana system, is confined to the neighbourhood of the eastern margin of the Indian peninsula. The Rarh country of Bengal and the whole of the Bihar alluvium are Old alluvium. The Old alluvium is under denudation, though occasional elevation by silt formation due to inundation also occurs at times. The New alluvium is ordinarily under formation and it has the tendency to rise, though occasional denudation and disappearance of whole tracts of New alluvium often takes pace in different localities. This general depression of Old alluvium and this general elevation of New alluvium are to be distinguished from the geological upheaval and depression that have taken place in the alluvial tracts of Bengal since the tertiary period. The elevation of the Tippera hill and the coast of Orissa, and the depression of the Gangetic delta by over 481 feet cannot be explained by alluvial action and denudation. There is some evidence to show that the drainage of the Indo-gangetic plain took place at one time by one delta only, *viz.*, the Delta of the Indus, and that the Gangetic Delta has been formed since the depression of the lower part of Bengal, facilitating drainage by a second delta. The extensive Madhupur jungles of Eastern Bengal are probably the remains of the Old alluvium which existed prior to this depression which has resulted in the accumulation of new alluvium in the greater portion of East Bengal.

25. Though the prevailing rocks of Bengal and Bihar are Old or New alluvium, there are some important exceptions. First of all we will describe the laterite region of Bengal, which is also post-tertiary. This laterite region can be traced up from Cape Comorin along the East coast, througn Orissa, Midnapur, Bankura, Burdwan, Birbhum, to the flanks of the Rajmehal hills as far as Patna. This fringe of laterite underlies the old alluvium and is older than alluvium. It is often seen capping older rocks. This is the High Level Laterite already described in Chapter I. The Low Level Laterite is truly alluvial and it occurs in patches throughout the Old alluvium of the Ganges valley.

26. The Pleistocene or glacial boulders and moraines are not represented in Bengal, except in the lower hills of Sikkim, Bhotan and Nepaul, down to a height of about 3,000ft. above the level of the sea.

27. Next we come across in Bengal a band of the Caddalore group of rocks,—sandstones, grits and clays, underlying laterite, from east of Raniganj extending northwards as far as Suri. These Caddalore sandstones &c., are tertiary. At a lower elevation in the Sub-Himalayan range, on the north of Bengal, there is a band of soft massive sandstones, also clays and conglomerates, resting on the older tertiary bed of Nummulitic limestone. This belongs to the same age as the Caddalore band from Raniganj to Suri.

28. The Eocene sandstones, Nummulitic limestones, and the cretaceous chalk, the pre-tertiary slates and sandstones are found in the Chittagong, Tippera, Garo and Manipur hills. Tertiary rocks prevail in these hills which were probably elevated at the post-tertiary age about the same time as the Gangetic delta from Rajmehal to the Garo hills was depressed.

29. The Jurassic system is next represented in Bengnl in the Rajmehal hills and the Upper Panchet series of rocks. The typical Rajmehal rock is a basalt or trap consisting of dark

coloured dolerite interstratified with a hard, white and grey and carbonaceous shale, white and grey sandstones and hard quartzose grit. Trap dykes and intrusions of the Rajmehal age are also abundant in the coal fields of the Damodar valley and dykes and cores of Basalt are common in Birbhum S. W. of Rajmehal. Trap-dykes diminish in the Damodar valley from E. to W. until in the S. W. of Hazaribagh volcanic intrusions disappear almost entirely. Further west, of course, occur the newer (Cretaceous) Deccan trap. The focus of eruption of the Rajmehal trap is at a point North of Raniganj. The Rajmehal beds extend to the east coast close up to Cuttack and southwards. Eastward, trap-dykes are less numerous but they occur throughout the upper Son valley and they gradually die out in Palamau only 200 miles W. of the ground in which the older lava flows of the Rajmehal age are seen and within less than 100 miles of the Gondwana basins in the Upper Damodar valley which are traversed by basalt dykes probably of the same age as the Rajmehal traps.

30. The Gondwana rocks appear in Bengal in the Damodar valley and in Chutia Nagpur. In the former, the upper and the lower Gondwana rocks are both observable at the basal portion of the Panchet hill and the Zemindari of Panchet, south of the Raniganj coal field. The lower Panchet beds consist of coarse felspathic and micaceous sandstones, usually white or greenish white in colour, with bands of red clay interstratified among the sandstones. The Panchet and Damuda rocks though often occurring in close proximity are of different age. The Panchet rocks are distinguishable from the typical Damudas by the presence of red clay and the absence of carbonaceous shales, and by the sandstone being usually more micaceous. Fragments of coal and shale are found in the conglomerates of the Panchet group, but they are evidently derived from the Damudas. The Dubrajpur rocks consisting of ferruginous sandstones and

conglomerates belong to the upper Gondwana age. The ridge of gneiss from the basaltic plateau of the Deccan to the Highlands of Chutia Nagpur is overlaid and crossed by Gondwana deposits stretching across from the Son to the Mahanadi. The watershed between the Son and the Mahanadi is pretty high and is occupied by Talcher rocks of no great thickness, so that gneiss forms the rock barrier from East to West. The Tributary mahals of Orissa also belong to the Gondwana series. The coarseness of the rocks, the prevalence of sandstones, the frequent occurrence of bands of conglomerate and the absence of marine fossil, characterise them as Gondwanas.

31. Then come the typical Damuda or Barrakar rocks belonging to the carboniferous system. The Barrakar river and its tributaries traverse the whole of this region. It passes round the western portion of the Raniganj coal-field and falls into the Damodar within the limits of the field. In the higher portion of its course the Barrakar receives streams which drain the Karharbari coal-fields which are supposed to be Talchers or the lowest Gondwana and not carboniferous. Conglomerates, sandstones, shales usually micaceous, and coal, characterise this region. The sandstones are felspathic consisting of grains of quartz and decomposed felspa . Knobs of calcareous concretions project through the sandstones. Felspar is at different places seen converted into pure Kaolin. White felspathic sandstone may be traced all the way from Raniganj to Chanda in the Central Provinces. Another typical Barrakar rock is conglomerate of rounded white quartz pebbles scattered over the surface of the soil.

32. Last of all we have the Archæan rocks of Bengal, metamorphic and submetamorphic, transition or Vindhyan. Small hills in Bihar appearing through the alluvium are most of them Lower Vindhyan and at the lowest level where the Ganges washes the base of the plateau at Chunar only Upper Vindhyans are exposed. The concealment of the Lower

Vindhyans here is probably due to the depression in the main axis of the basin. The Lower Vindhyan rocks of the Son valley consist of limestones, shale, sandstone, shaley sandstone, trappoid beds, porcellanic shales, and conglomeratic and calcareous sandstone. True metamorphic rocks, *viz.*, gneiss and granitoids, encroach upon the zone of the transition rocks in Bihar where for some miles north of the Grand Trunk Road, west of Gaya, gneiss reaches quite across the strike of the slates. Several hills isolated on the alluvial plain in this neighbourhood are of thorough granite. Immediately east of Gaya transition rocks appear again on the prolongation of those on the Son valley and having the same strike. They form several groups of hills in East Bihar, known as the Maher, Rajagriha, Shaikhpura, and Gidhour hills, which stand clear of the main gneissic area and more or less isolated in the alluvial plains, and those of Mohabar and Bhiaura on the northern margin of the gneissic upland. All these isolated Bihar rocks belong to one system, massive quartzites appearing on the sides of the hills and the associated schists or slates appearing obscurely in the valleys. On the north side of the Bhiaura ridge the bottom quartzites lie steeply against the "dome gneiss" as the peculiar rounded and poised masses of gneiss are called. Elsewhere schistose gneiss occurs at the boundary. True granitic intrusion may be observed in the soft earthy schists. In the neighbourhood of Gaya many forms of special metamorphism and of contact action are well exhibited. At Lukhisarai the quartzite rests against an amorphous mass of pseudo-crystalline granitoid rock of much less sharply defined texture than at Shaikhpura in which strings of pebbles can be detected. This amorphous mass rests on beds of coarse conglomerate. Another outcrop of conglomeratic schist appears in the east end of the Gidhour range.

33. The gneissic uplands of Hazaribagh in Chutia Nagpur,

about 120 miles wide, separate the transition rocks of Bihar from those which occupy parts of Manbhum and Singbhum in South-West Bengal and stretch far to the west, the whole transition area here being 150 miles long from east to west and 80 miles wide. The prevailing character of the rocks here may be best explained by an enumeration of the principal kinds that occur on the surface. These are quartzite, quartzitic sandstone, slate, shales, hornblendic, micaceous, talcose and chloritic schists passing into bedded trap, shales with ripple marks so little metamorphosed that they might be mistaken for Talchers, or the Lowest Gondwana shales, but for veins of quartz penetrating through them. The Chutia Nagpur gneiss is interbedded with micaceous, hornblendic and sileceous schists, and occasionally bands of porphyritic granite and highly metamorphic schists. In Singhbhum the oldest or Bundelkhund gneiss is seen in junction with transition rocks, interpenetrated by trap dykes. Sandstones and mudstones, resting immediately on the rough and weathered surface of the granitic gneiss traversed by trapdykes, is the prevailing character of the Singhbhum soil. "Dome Gneiss" prevails in the northern fringe of the Hazaribagh plateau and the Mandar hill of Bhagalpur. Trapdykes though common in the Bundelkhund gneiss are rare in the Bengal gneiss. We do not see the same extensive basaltic intrusions in southern Monghyr, Hazaribagh and Chutia Nagpur as we do in Birbhum where they belong not to the archæan but to the Rajmehal age.

34. We have thus seen that although the prevailing character of the soil of Bengal and Bihar is alluvial, either old or new, we have important exceptions all over the outlying districts, where rocks of older epochs prevail.

35. The age of rocks can be only vaguely guessed by their texture. The study of fossils alone gives us exact clue as to which period a particular sandstone, or a particular limestone, or a particular shale, belongs.

As agriculturists you should be able to judge from the external appearance of soils and sub-soils and with such rough and ready test as is afforded by a little hydrochloric acid, their general character and composition, and a knowledge of the principal minerals and of the method of distinguishing and testing them will help you to judge still better whether a soil is rich or poor and whether it is capable of much improvement by the utilization of local resources. You have been told the value of trap-rocks in the formation of rich soils. The presence of a large variety of rocks is also of great value in forming rich soils. A valley or a plain situated near a hill where shales, sandstones, limestones and felspathic granite or gneiss occur in abundance must be rich in plant food. The junction of two geological formations is always rich. The alluvial deposits differ in character according to the difference in the character of rocks composing the hills from which they are derived. Usually, however, alluvial soils abound in plant foods, especially the farther they are situated away from mountains. The delta of the Ganges represents washings of the finer particles of all the Bengal hills, and what is of great importance, it is full of organic matter being the receptacle of the drainage of a large and populous tract of country and of hills abounding in forests. The combination of minerals and organic matter is far greater in the lower part of the basin of the Ganges than in the upper parts. But where in the upper parts of the basin the soil is clearly derived from felspathic granite or trap-rocks and limestones, it is richer than alluvium.

CHAPTER III.

FORMATION OF SOILS.

SOILS are formed by the weathering and disintegration of rocks. Soils are either *sedentary*, that is, formed out of the underlying rocks, or *transported*, that is, formed out of the disintegrated parts of rocks, brought down mainly by fluvial action from a distance. Sedimentary rocks containing fossil remains of plants were soils at some ancient geological period. The superposition of layer after layer of silt on them resulted in their getting compacted and solidified under pressure. By volcanic action these solidified masses coming again to the surface or being bulged up in the form of mountains became once more subject to the action of rain and heat and cold and the atmosphere, and once more they were weathered and converted into soils. In geological language the loose top soil is also a rock, and in some future age what is now soil with herbs and trees growing on it, will become a fossil-bearing hard rock with other rocks superposed on it. Underneath the loose matting of earth both in land and in sea there is the uneven pavement of stone, jutting out into high mountains or sinking deep in valleys and ravines or extending far and wide in plains and table-lands. There are mountains and valleys and plains both in sea and on land. The agriculturist is mainly concerned with the loose matting of soil and subsoil on dry land and scarcely at all with the stone pavement underneath, unless it occurs within easy depth, in which case he can get building-stones, coals, or other minerals, or even valuable manurial substances for improving his soil by digging down a short depth or carrying from a short distance. An admixture of 10 to 15% of small stones of the right kinds with agricultural soils, is not undesirable, as these

contain valuable reserve materials of food which gradually get dissolved and made available as plant food. But an admixture of large sized stones in the soil is certainly not desirable, as they interfere with proper aerification of soil, germination of seed and penetration of roots. The agriculturist should not only have an idea of the composition of his soil and of the stones which are found in the soil, but also of the subsoil or the soil immediately below the surface soil interpenetrated with the roots of deep-rooted plants. The subsoil is more compact in appearance and is usually of a lighter colour. It is very important that the subsoil should be richer than the soil, and if the soil is sedentary, that the underlying rock should be composed of substances which are valuable for plant life. In transported soils also, valuable minerals, such as *ghuting* lime or kankar and gypsum may be found buried within easy reach of the surface. Chemical analysis does not always give a correct idea of the actual present value of a soil, subsoil, or rock, but it tells us of their possible ultimate value. In a hard rock scarcely any plant food exists in an available form, and nothing will grow on such rock. In the case of soils also a great deal depends on cultivation and not on their potential richness as found out by chemical analysis. Analysis, for instance, shows, that the soil of the Sibpur Experimental Farm is richer than those of the Burdwan and the Dumraon Experimental Farms. But we actually get at Sibpur poorer crops. The soil of the Sibpur Farm is a hard clay which is difficult and more expensive to cultivate and under the same treatment this soil does not yield such heavy crops as soils actually poorer but which are easier to cultivate. Nevertheless a knowledge of the composition of soils and rocks is of great practical value to the scientific farmer. He knows what plant food there is, and it rests with him how much of it he can or he ought to make available for a certain crop. A soil may be too fertile and the fertility of a soil may be too quickly exhausted. Deep

ploughing will give better results and so will liming for a time, but these processes are exhausting and it is for the farmer to judge whether his soil is capable of such exhaustive operations. For exhausting and valuable crops, deep ploughing, burning, liming and other exhausting processes are advisable if the soil is rich, but by bringing too large a quantity of food into a soluble state and by letting chiefly rain to wash it out of your land, though you may get one or two heavier crops, you only impoverish your soil in the long run. Chemical analysis is therefore a reliable guide for ascertaining the value of rocks and soils, as the farmer has it in his power to utilise that value slowly or quickly according to his needs by the judicious application of tillage and by manuring.

37. Though chemical analysis alone gives one the right clue as to the composition and nature of rocks and soils, their external characters often give a rough idea as to what they are and what to expect of them. Indeed the scientific farmer depends more on rough and ready tests than on careful chemical analysis for judging soils, rocks and minerals. He looks at a dark coloured soil and concludes it is rich in Nitrogen and Potash and suitable for growing corn. He looks at a yellow soil and concludes it is rich in phosphorus and lime and other mineral matters, and suitable for growing root-crops, fruits as well as corn. He looks at a light coloured soil and concludes it is chiefly sand and will grow only mustard and rape and *kalai* to perfection. He looks at a field overgrown with rich and wild vegetation of various kinds, rank grasses, leguminous plants, and creepers, he digs it with his spud and finds he can easily manage that, and while digging he notices dead shells and channels made by earthworms and he concludes, it is rich friable loam, and he prefers it to all the others. The dark coloured soil, first mentioned, though rich, and though it may show on chemical analysis to contain a larger proportion of phosphorus, lime, and other mineral plant

foods as well as organic plant food, is perhaps a stiff clay which he finds it difficult to dig with his spud and on the surface of which he notices deep and wide cracks and though he knows it to be richer he will not prefer it for ordinary agricultural crops though he will for permanent pasture and for such perennial crops, as Rhea, Abroma augusta, Tapioca and such agricultural crops as take long growing, such as *arahar* and sugarcane. If he can afford to keep it in proper tilth and if there are special facilities for irrigation he will prefer clay soil to loam, unless the clay is too stiff. Different soils are particularly adapted for particular crops, and when one cannot choose his soil one can at least choose his crops. By cultivation and manuring it is possible to a limited extent to alter the natural adaptability of certain soils to certain crops and these should not be lost sight of, in any case. Even barren *Usar* land has been rendered fertile by proper treatment.

38. It has been said that certain stratified rocks were loose workable soil in former geological periods. Hence we find imbedded in hard rocks, fossils of plants and animals that once grew on the soil or disported themselves over it. As the remains of animals and plants are very valuable as plant food, rocks showing an abundance of fossils, such as certain sandstones and all limestones are productive of very fertile soils. The recognition of fossils is thus of some practical importance to farmers. The fertilising property of the rocks of the crystalline group, *viz.*, archaic and metamorphic rocks, consists chiefly in the presence of an abundance of Felspar. Mica is of less importance and quartz is of least. All sedimentary rocks and soils being ultimately derived from these crystalline rocks, a knowledge of the composition of these is of value. Mica-schist consists of quartz and mica and a soil formed out of mica-schist is therefore poor. Gneiss is the same as granite in composition only it is sedimentary and metamorphic or become compact and crystalline by the

joint action of heat and pressure. Granites, though consisting of felspar, mica and quartz, vary very much in composition according to the proportion in which these minerals occur. The larger the proportion of felspar in granite the richer it is for the purpose of formation of soils. Trap-rocks and volcanic tuffs form the richest soils, and a study of the minerals which compose these is of great importance.

39. The agencies operating in the disintegration of soils are: (1) Aqueous, (2) Atmospheric, (3) Physical and (4) Organic.

(1) Aqueous agency in the disintegration of rocks and soils is the most potent of all. What enormous quantities of solid matter in large and small sizes are dislocated by rain and brought down by streams and cataracts and rivers, may be judged from Everest's calculation of silt carried down by the Ganges alone. Everest calculated that 355,361,464 tons of solid matter are carried down annually to the sea by the Ganges. If 1000 ships laden with about 1000 tons of mud daily were employed in emptying their contents into the sea, they would perform the same work which is done by the Ganges. The Brahmaputra carries to the sea a still larger quantity of silt. The hardest and heaviest rocks become converted into rounded boulders and pebbles by the action of the moving water containing sand in motion. Water acts not only mechanically in denuding rocks but it is also a solvent. The potash, soda, silica, and lime get dissolved in water and rocks may be denuded simply by the solvent action of water. The solvent action of water or minerals is increased by its containing salts in solution and gases in suspension. Besides disintegration due to rainfall and the denudation due to rivers and waterfalls, we have a third form of aqueous agency in operation: sea waves beating against cliffs help in the formation of soils. The action of glaciers in tearing down rocks and in the formation of moraines and erratic boulders may be also included under this head. The hydration of rocks in the presence of water should be also mentioned here.

(2) Atmospheric agency acts on rocks chiefly in four ways. First, the carbon dioxide gas renders the calcium carbonate soluble. Limestones, chalk and *kankar* thus get dissolved and available as plant food, and the rain-water from calcareous rocks charged with calcium carbonate, flows into the sea where shell-fish and corals and foraminifera utilise the lime in building up their own bodies, which in time settle in the form of dead shells and form new rocks. Secondly, the dew and water vapour of the atmosphere getting into the interstices of rocks in cold regions become congealed and the expansion resulting from this has the effect of disintegrating particles of rocks. Thirdly, the Oxygen of the Atmosphere is a very potent agent for oxidizing and disintegrating surfaces of hard rocks. Fourthly, strong currents of wind carry sand and finer particles of matter from sea-shore and dry beds of rivers into the interior.

(3) Physical agency operates in disintegrating soils chiefly in the form of heat. Earthquakes, hot-springs and volcanoes have the tendency to alter even the superficial layers of the earth's surface more than we think they do; but these agencies were more potent in past ages than now. Electric agency is also at work. The water-vapour and the free nitrogen of the atmosphere combine in the presence of lightning and thunder in the form of nitric acid which being brought down by rain acts on the rocks and helps to dissolve their particles more quickly.

(4) Organic agencies are at work in various forms. Minute bacteria are continually at work in soils and on the surface of rocks. Higher forms of vegetation,—lichens, mosses, grasses, shrubs, creepers and trees are also most potent in disintegrating rocks. Animal life also is at work chiefly in the sea in the formation of soils. Coralreefs, Chalk cliffs, Nummulitic and other limestones and marls, consist of dead shells chiefly of marine animals, large and

small. The lime carried in solution by rivers to the sea goes to form the shells of these animals. The Silica carried in solution to the sea is used by a minute animal called Radiolaria in the formation of its body or rather the shell round its body. Tripoli-earth and Barbadoes-earth used for grinding purposes are old Radiolarian deposits like chalk is old foraminiferous deposit.

40. Light diatomaceous earth is of vegetable origin ; but the earth is nearly pure silica. Landshells, caterpillars, moles, voles, musk-shrews, and pigs may be also mentioned as Nature's cultivators, though they are also to be regarded in the light of pests. Locusts which are the worst of all pests may be also regarded in the light of Nature's fertilizers. If locusts are frightened and prevented from alighting, they may not do any damage but simply leave a thick deposit of droppings, rich in manurial substances culled from forests, all along their track.

41. Earth-worms have also considerable influence in the formation of soils and in altering their character. They derive nourishment from soil which passes through their intestinal canal, some of the organic matter being digested, while the whole of the earth is mixed up and triturated inside the canal. Worm-casts are particularly useful to the farmer, as they help to loosen and perforate the soil for penetration of roots, water and air. Worms also drag down leaves, pieces of straw &c. into their holes, thus incorporating organic matter into the soil, and making heavy soils lighter and light soils heavier. The presence of earth-worms on grass-land consisting of a shallow layer of soil resting on hard rocks is particularly beneficial in gradually adding to the depth of the soil in an imperceptible manner. Darwin computed that an acre of garden soil contains on an average about 50,000 earth-worms, and in ordinary arable soils about half this number. In good soils 10 tons of dry earth is passed through the intestines of earth-worms annually and

the surface deposit of casts is ·22″ per annum. Even in poor soils a surface deposit of ·08″ per annum has been estimated. As earth-worms go down several feet deep and come up again, the mixing of the soil effected by them is often more efficacious than that effected by cultivation.

42. It has been observed that a stream of lava takes sometimes several years to cool. Even when cool it is incapable of supporting higher vegetable life. Disintegration takes place by hydration, oxidation and physical action. Nitrification then proceeds with the help of Bacteria. Then lichens and other minute vegetation are observed to appear. Gradually the quantity of soil on the hard surface of the rock increases, and the growth of vegetation becomes more vigorous,—mosses, ferns and grasses gradually taking the place of lichens. When visible soil accumulates and fissures and cracks appear on the rock, herbs and shrubs multiply and by their root—action further help to disintegrate the rock to some depth. The formation of soils now goes on apace. Lichens and bacteria are able to draw nourishment from the most insoluble rocks,—not only basalts, granites and schists, but also quartz. Even quartz gets covered with lichens when exposed long enough to air. Some lichens contain a good deal of oxalic acid, and limestones which have been long exposed, generate calcium oxalate by the action of lichens. The action of higher vegetation on rocks is partly mechanical and partly chemical. Roots get into the clefts of rocks and tear them asunder. The chemical action is concerned in the solution of some of the ingredients of the rock. The solvent action of roots is due to the formation of acids in them which act on particles of soil. All plants, large or small, die each year wholly or partly and deposit their dead organic matter on the rock. The falling leaves, seeds, &c., when they accumulate in forests, marshes or bogs, produce a black or brown mass which is called Humus. By decay of roots of plants also, a similar substance is formed.

When organic matter decays in very high temperature, the Carbon and Hydrogen may get entirely oxidized into Co_2 and H_2O, but with limited access of air the oxidation is slow and the formation of bodies which resist decay for a long time is the result. These are found in the lower layers of turfs and in meadows and forests. The humus so formed is of a complex composition. The acids and other organic substances formed are not clearly understood. The commonest are humic acid ($C_{20}H_{12}O_6$) Ulmic acid ($C_{20}H_{14}O_6$), Geic acid ($C_{20}H_{12}O_7$), Crenic acid and Apocrenic acid. The composition of Crenic and Apocrenic acids, discovered by Berzilius, is uncertain. All these compounds retain ammonia with great tenacity. Humus is also a highly hygroscopic substance tending to keep rocks moist and thus helping their further disintegration by hydration. The generation of CO_2 in humus is profuse and constant. The air of all soils contains a much higher proportion of CO_2 than ordinary atmospheric air, which contains only 4 or 5 parts of CO_2 in 10,000 parts, while the air in soils contains from 10 to 250 parts of CO_2 in 10,000 parts. The organic acids and CO_2 of humus assist in the decomposition of minerals. The nitrogenous matters of humus are gradually converted into ammonia-salts and nitrates, especially inthe presence of lime and nitrifying bacteria. These salts in their turn assist in disintegration. Plants thus have the effect of disintegrating rocks in various ways, both in their live and dead state. Not only limestones but even quartz and other hard silicates are found eaten into by roots of plants. Clubmosses which contain a good deal of Al_2O_3 (which is not an essential constituent of every plant), are of great help in disintegrating rocks containing alumina. Of agricultural plants, mangold wurzel and *Chuká-Pálam*, containing a good deal of oxalic acid, have a considerable power of assimilating phosphates from the soil, and they have also considerable power of disintegrating rocks.

43. The decay of organic matter helped by the various processes described, results in a supply of Phosphoric acid, and Nitrogen in an available form is also supplied for the nourishment of plants. Generally speaking the more organic matter there is in a soil the more nitrogen does it contain, and the proportion of organic matter may be roughly considered as a direct measure of the fertility of a soil. Generally speaking also the more mixed a soil is (*i.e.* the larger the number of rocks and minerals out of which it is formed) the more fertile it is. Hence alluvial soils, and soils formed at the junction of two geological formations, are more fertile than soils resting on single formations.

CHAPTER IV.

PHYSICAL CLASSIFICATION OF SOILS.

THE classification of soils into Sedentary (or Indigenous) and Transported has been already mentioned. Transported soils are again subdivided into Diluvial and Alluvial. Diluvial or Drift soil consists of soil proper mixed up with stones and boulders. These are usually formed from various kinds of rocks. Alluvial soil consists of fragments or particles of minerals arranged according to their size and also partly according to their specific gravity. Alluvial soils are, as a rule, more fertile containing fragments of rocks of different geological periods. Alluvial soils mixed with more or less angular fragments of rocks on which they lie are called Colluvial.

45. Soils are also classed as Light and Heavy, Warm and Cold, Moist and Dry. They are also classified according to the crops which do best on them, or which ought to be grown on them for economical reasons. Richest soils are called *garden soils;* middling clay loam soils, *wheat soils;* hard clay which is expensive to work, *pasture soil;* poor harsh land, *wood soil.* Soils are also classified according to their prevailing physical constituents. These are, stone, gravel grit, sand, clay, calcium carbonate, vegetable matter and moisture. Soils are thus divided into stony, gravelly, gritty, sandy, clayey, calcareous, peaty and marshy. There is however no hard and fast distinction between one group and the next.

It is difficult to say where sand begins and grit ends or where stone ends and gravel begins. Sand may be again siliceous, or micaceous, or calcareous, or felspathic. Stones and pebbles are not immediately useful for plant life but they serve useful purpose in retaining moisture and acting as a reserve of plant food. Stoney soils therefore though usually poor are not so necessarily, and some stoney soils, *viz.*, those which contain chiefly fossils, limestones, basaltic stones, and felspars, are rich.

46. The *mechanical analysis* of soils is done by sifting and washing. Sifting separates the coarser particles and washing the finer particles. The sample of soil to be analysed is to be spread on the floor of a dry and warm room ; lumps are to be broken up and crushed as drying proceeds. The large *stones* are then to be picked out, cleaned, dried and weighed. The dry soil is then to be passed through a sieve the meshes of which are 3 mm. in diameter. That which passes through is weighed as *fine earth*, and what remains on the sieve as *gravel*. The gravel is further washed and dried and weighed again as *true gravel*. The fine earth is then boiled for an hour to break up lumps, and it is then introduced into a *washing apparatus* (*e.g.*, Schulz's apparatus) in which by introducing a flow of water at different rates, first the finest suspended matter is washed away, and then successively the finest sand and coarser sand.

47. Another process of mechanical analysis of soils consists in arranging a series of vessels side by side and allowing the water from the one to flow into the next. This also divides the soil into portions of different consistency. For either process it is necessary finally to let the water evaporate completely from each vessel of water and to weigh the dry residue. This analysis enables us to separate the soil into (1) stones ; (2) mechanical gravel ; (3) coarse sand ; (4) fine sand ; (5) finest sand, and (6) clay and impalpable matter. Clay soil proper is that which contains only clay

and impalpable matter. Soils which have the physical property of clay may contain no clay in the chemical sense *i.e.*, silicate of aluminum. The composition of chemically pure clay may be represented by the formula $Al_2O_3.2\ SiO_2.2H_2O$.

48. A more rough and ready method of mechanical analysis consists in taking an ounce of soil, mixing it up with a pint of water, leaving it in the water for 24 hours, then shaking it up and allowing the heavier particles to settle for 5 minutes. The supernatant liquid can then be poured into another vessel which may be allowed to stand for another 24 hours. The sandy part will be seen settled in one vessel and the clayey part in the other. These may be dried and weighed separately.

49. If 100 grains of dry soil, not peaty or unusually rich in vegetable matter, leave no more than 10 of clay treated in this manner, it is called *sandy soil ;* if from 10 to 40 *sandy loam ;* if from 40 to 70 a *loamy soil ;* if from 70 to 85, a *clay loam ;* from 85 to 95, a *strong clay soil ;* and when no sand is separated at all by this process, it is a pure *agricultural clay.* This pure clay contains silica and alumina in the proportion of about 60 of the former to 40 of the latter but the composition of agricultural clay is very uncertain. It rarely happens, however, that arable land should contain more than 30 to 35 per cent of alumina. Soil containing more than 5°/₀ of carbonate of lime is called *marl*, and more than 20°/₀, *calcareous soil. Peaty soils* contain more than 5°/₀ of humus or vegetable mould. Ferrugenous soils contain over 5°/₀ of iron.

50. For practical purposes, however, the systems of classification of soils in vogue in Bengal and in the other Presidencies are numerous. They are based on various *fundamenta divisiones.* Land is classified, for instance, as irrigated, irrigable and non-irrigable ; also as *ek-phashli* and *do-phashli* or single-cropped and double-cropped ; also as cultivated, culturable and non-culturable. The cultivated land may be

also divided according to crops, *e.g.*, suna or *Bhadoi* land and shali or low land suitable for *aman* paddy (called also *aghani* land) and *rabi* land. Vegetables, *arahar,* and sugarcane are classed with *rabi* crops, indigo with *Bhadoi* crops and sweet potatoes with *aghani* crops. *Pan* garden is curiously enough classified with uncropped area in settlement operations in Bengal (vide p. 28 of Hand-book of Instructions for Cadastral survey parties for Bengal, by Lieutenant-Colonel W. Barron, 1886) and thatching grass also. The culturable area is subdivided into (1) New or less than 3 years' fallow; (2) Old Fallow; (3) Groves; (4) Grass; (5) Bush; (6) other kinds (including *pan* gardens, forest, bamboo clumps, threshing floors, waste adjoining village sites, temporary sheds, pathways and excavations). The non-culturable area is subdivided into (1) Village site; (2) Sites of temples aud burial grounds; (3) Unculturable waste as "usar"; (4) Tanks; (5) Rivers; (6) Unculturable Jhils and Churs; (7) Government roads; (8) other roads; (9) other kinds of unculturable lands (*e.g.* encamping grounds, embankments, mounds, railroads, barracks, bungalows, brick and lime kilns, permanent cattle-sheds, serais &c.). Land is also classified as *áwál, doem, soem* and *cháháram*, or 1st, 2nd, 3rd and 4th class; also as (1) *Bastu,* (2) *Udbastu,* (3) Garden, (4) Bamboo and orchard, (5) *mathan,* (6) *bilan,* and (7) *dearh.* Each of these is subdivided into *áwál, doem, soem* and *cháháram.* Lands are also classified according to proprietary rights: *e.g.* (1) Permanently Settled lands; (2) Waste-lands for which revenue has never been settled; (3) Temporarily settled estates or tenures the property of Government or of private individuals (—of Government again on expiration of the term of the current settlement); (4) Estates or tenures purchased on account of Government or escheated or forfeited to Government; (5) Resumed revenue free lands; (6) Islands thrown up in navigable rivers; (7) Alluvial accretions; (8) Lands acquired but no longer required

for public purposes ; (9) Lands annexed by conquest; (10) Occupancy holding; (11) Non-occupancy Khudkasta and Paikasta holdings. A revenue officer describing a piece of land has thus several principles of classification to bear in mind. They all have some relation to the intrinsic value of the soil; and the farmer also must look into all these principles before deciding the value of a property he wishes to buy for agricultural purposes. The fixity of tenure and of rent is of the utmost value to the tenant in encouraging him to go in for agricultural improvements.

51. The following considerations also affect the value of land ;—

(1) Climate, healthy or unhealthy.

(2) Whether local labour is abundant, industrious and skilful.

(3) Amount of rainfall.

(4) Whether the tract has been subject to famine or local failure of crops due to drought or inundations.

(5) Whether the land is level and well exposed to sunshine, or whether it is steep ravine land.

(6) Distance from the purchaser's residence.

(7) Vicinity to good markets.

(8) Means of communication with the markets.

(9) Facilities for irrigation ;—depth of water in wells.

(10) Depredations by cattle, wild boars, rabbits, &c.

(11) Local supply of manures.

52. In the N.-W. P. the following classification of soils is generally in vogue :—

1*st.*—*Gohani* land or land near villages and towns. In village *gohani* land the crops usually grown are, wheat, *gur*-making sugarcane or *ukh,* vegetables, maize, radish, carrots and *chillies*. In town *gohani* land market gardening is practised, *i. e.* the growing of potatoes, cabbages and cauliflower, chewing canes or *poundas* and tobacco.

2*nd.*—*Loam.* Wheat, barley, gram, *jowar,* cotton, with

arahar, and maize are usually grown on such lands. *Jowar*, *Bajra* and cotton are grown, as a rule, with *arahar* both on *gohani* and loamy soils. When the land is very rich, *arahar* which occupies it for a whole year, is not grown in mixture.

3rd.—Sandy loam.—Bajra, *Kalai*, Barley with gram, *Jowar*, mustard with wheat and other *Rabi* crops, are grown on such soils.

4th.—Clay loam.—Barley mixed with gram (or gram alone) or with pea (or pea alone), sugarcane, *Mung* and paddy are grown on such soils.

5th.—Clay soil near tanks.—The same crops are chosen for such soils as for clay loam. Only these are harder to work and being more subject to floods are more uncertain.

6th.—Bhur or Sandy soils.—(*a*) near rivers (*dearh land*) suitable for growing melons and *Kankries:* (*b*) in fields, suitable for growing *Bajrá* along with *Til* or *Kalai* or *Mung*, also Barley with wheat or mustard.

7th.—Kankreli soil.—Full of Calcareous nodules, suitable for growing gram and leguminous crops generally. *Bajra*, *jowar*, *urd*, gram, barley, pea and mustard are the usual crops grown on *Kankreli* soils.

53. In the Madras Presidency the following classification of soils is generally in vogue :—*1st.—Karisol*, or Black soil, No. 1 and No. 2. *2nd.—Seval*, or Red loam, No. 1 and No. 2. *3rd.—Guruman*, or Clay loam, No. 1 and No. 2. *4th.—Veppal*, or dry and hungry sandy soil, which is so common in Madras, No. 1 and No. 2. *5th.—Pottal*, or barren soil, either too saline or too ferruginous (laterite).

54. In the Central Provinces the recognised divisions are *Kali* Nos. 1 and 2 (*i.e.* Black soil) ; *Morun* Nos. 1 and 2 (Loam) ; *Kherdi* Nos. 1 and 2 (Sandy soil) ; and *Berdi* Nos. 1 and 2 (Stony soil).

55. In the Bombay Presidency, Revenue officers follow a very systematic method of classifying soils. This method how-

ever is unsuitable for deep alluvial soils where depth is of no practical value for classifying soils which are all very deep. Soils in Bombay are divided into nine classes according to their depth and 3 orders according to their colour and texture. The following table gives an idea of the system followed :—

Class.	Anna valuation.	Order I. Uniform fine texture, black to dark brown in colour.	Order II. Uniform coarse texture, lighter in colour, usually red.	Order III. Gravelly or loose, friable texture, colour light brown to grey.	Remarks.
1	16	1¾ cubits or more	.....	.....	A greater depth than 1¾ cubits does not affect the fertility of land. Soils of the 3rd order are never more than 1 cubit deep. If the rent of the 1st class soil is Re. 1 that of the 9th class soil is estimated at 2 as.
2	14	1½ cubits	1¾ cubits or more	.....	
3	12	1¼ ,,	1½ cubits	.....	
4	10	1 ,,	1¼ ,,	.....	
5	8	¾ ,,	1 ,,	.....	
6	6	½ ,,	¾ ,,	1 cubit.	
7	4½	¼ ,,	½ ,,	¾ ,,	
8	3	.....	¼ ,,	½ ,,	
9	2	.....	.....	¼ ,,	

56. The following conventional signs for peculiarities or defects of soils are in use in the Bombay Presidency :—

°°° Denotes a mixture containing nodules of limestone.

V An inordinate admixture of sand.

/ A sloping surface.

X Absence of cohesion among soil particles.

Λ More or less imperviousness to water.

~~ Liability to be swept away by running water.

▭ Excess of surface water.

57. Besides the ordinary division into *tilth* and *subsoil*, layers known as *pans* sometimes occur. These are of three kinds: (1) *Moor-band pan* which exists as an impervious deposit a few inches below the surface. Salts of iron combining with dead plants washed down by rain, oxidise and form a cement which require to be broken up by a strong subsoiler. (2) *Calcareous pan* is the result of long continued shallow ploughing of soils rich in lime, the lime sinking gradually and forming a cement; (3) Hard *pan*. The cementing material in this case may be oxide of iron or alkaline silicates or calcium carbonate. *Pans* should be broken up by deep ploughing.

CHAPTER V.

CHEMICAL CLASSIFICATION OF SOILS.

PLANTS derive the bulk of their food from the air and from water. The largest proportion of a plant consists either of carbon or of water. Potatoes contain as much as 75% of water, carrots and beet 80 or 90%, a tree felled when the leaves have shed in the cold weather contains from 30 to 50% of water, and when it is in leaf it contains 40 to 60% of water. The carbon or the charcoal portion of a plant also varies very much but it usually comes next in importance to water. The carbon is fixed in plants with the help of sunlight acting on chlorophyll granules, out of the Co_2 of the air. Air contains about 4 parts of Co_2 in every 10,000 parts and the carbon of plants is therefore derived without any trouble on the part of the cultivator. The nitrogen of plants is partly derived from the atmosphere by means of rainfall without any trouble, but it is also derived mainly from the soil and

manures applied to it. The presence of nitrates and ammonia in the soil is therefore of great importance. In fact the amount of N. present in a soil mainly determines its value. Besides water, carbon, and nitrogen, there are also certain other constituents of plants which are essential, though usually occurring in minuter proportions. Plants depend entirely on soils for these minute but essential constituents. When a plant is burnt into ashes, its carbon, water and nitrogen pass away, and the ash left always contains the following:—Phosphoric acid, Sulphuric acid, potash, lime, magnesia and iron as protoxide (FeO) and Sesquioxide (Fe_2O_3). Soda, Alumina, Silica and Chlorine are also nearly always present, but some plants can do without these food constituents.

59. According to the chemical requirements of plants, soils can be divided into: (1) Aqueous or moist soils, (2) Nitrogenous soils; (3) Phosphatic soils; (4) Potassic soils; (5) Calcareous soils; (6) Ferruginous soils; (7) Siliceous soils; (8) Alkali soils (containing an abundance of CaO, MgO, Na_2O and K_2O) and (9) Sulphurous soils. Water is of the highest value, then nitrogen, then phosphorus, then potash, then lime, then sulphur, then iron and lastly silica, chlorine and soda. The physical importance of Silica or Sand, as making the soil freer and lighter to work and for roots to penetrate, is very great, but not its chemical importance. The importance of Chlorine and Soda (*i.e.* of common salt) for certain crops such as cocoanut, mangoes, beet, radishes, potatoes, cabbages, cashewnuts, date, breadfruit tree, asparagus, is undoubted, but the presence of these is not essential in the soil for every crop. K_2O can replace Na_2O in some plants, and the presence of K_2O is therefore doubly important. The absence of any of the essential constituents of plants just enumerated makes a soil quite sterile. But it is rare to meet with a soil wanting altogether in moisture, or nitrogen, or phosphoric acid, or potash, or lime, or magnesia, or iron, or sulphuric

acid. Plants generally grow in any soil which contains a sufficient proportion of these. The presence of an excess of certain salts or of some substances poisonous to plants may render the soil sterile in spite of the presence in sufficient quantities of all the essential constituents. Nearly every soil contains all the essential constituents for the growth of vegetation, and even the well water or drainage water percolating through soils contains all the essential constituents for the growth of vegetation, so much so, that water-culture with such well or drainage water alone has been successful with reference to a good many plants including oats. It is from solutions that plants can absorb food. The solubility is helped by the organic acids and the carbon-dioxide excreted by the rootlets. Soil digested in water ought to part with 1 part of solid for every 1000 parts of water for plants to make proper use of the solid. If over 2 parts of solid are dissolved in 1000 parts of water the rootlets cannot make proper use of the food, nor if less than ·5 part in 1000 parts. A soil can be too rich in soluble plant foods or too poor, as the solubility is required to be in a certain dilution. A soil becomes too rich if in the dry season it is manured with fresh urine which contains nearly 2 per cent of urea, a substance which can be directly used by plants as food. But a 2 per cent solution even of a valuable plant-food is at least 10 times too rich. This accounts for Bengal cultivators regarding urine as injurious to crops though it is really more valuable in the fresh state than cowdung. Diluted with ten times as much water urine proves a most excellent fertilizer of soils. As nearly all soils contain all constituents of plant food, the chemical classification of soils is based not on absolute but only on relative grounds.

60. Schubler's classification is based on a consideration of only four of the proximate constituents of soils, *viz.*, Humus, Lime, Clay and Sand. It takes no note of the proportion of N, P_2O_5 and K_2O which are the important constituents

of soils, the excess or deficiency of which chiefly determines the fertility or barrenness of soils. Schubler's classification, however, has the merit of being easily applicable in practice to ordinary farming, as it does not depend on elaborate chemical analysis but only on such rough and ready methods of analysis as an intelligent and educated farmer can easily command.

61. To determine the class of any soil according to Schubler's Table, the following direction should be followed :

(1) Take 100 grains of a well pulverized soil after drying it for ½ an hour in an air or oil both at 250°F. Heat it in a platinum crucible for half an hour, stirring the mass occasionally. Cool in a dessicator and weigh. The loss of weight is calculated as *Humus*.

(2) Digest the residue in the platinum crucible in a phial with cold diluted Hydrochloric acid in the proportion of ½ ounce of acid to 10 ounces of water to 100 grains of dry soil : Let the digesting go on for half an hour with occasional stirring. Filter through a weighed filter paper, wash with distilled water, until the water passing through ceases to give acid reaction tested with litmus paper. Dry the whole at 250°F. ; weigh the substance in the filter paper ; deduct the weight of the filter paper. The loss of weight represents the amount of lime.

(3) The contents of the filter paper are now carefully removed into a tall glass cylinder, and the impalpable matter separated from the sand and coarser particles by repeated washing with water. Stir well, let subside for a minute and pour off the supernatant liquid. The impalpable matter thus separated is collected on a filter, dried as before and weighed. The weight represents the weight of clay.

(4) The remainder is sand.

62. Proceeding on the above method we can refer any soil to Schubler's Table which is given below.

Schubler's Classification and Nomenclature of Soils.

Names of the different Descriptions of Soils.			Proportions of Ingredients in every 100 Parts.				Remarks.
Classes.	Orders.	Species.	Clay.	Lime.	Humus.	Sand.	
1. *Argillaceous or Clayey Soils.* Above 50 per cent. of Clay Not more than 5 per cent. of Lime	Without Lime	Poor	Above 50	0	0·0 to 0·5	The Remainder	(*Paddy Land*) Sugarcane, paddy, arahar, gram, peas, beans, mung, barley, linseed, cabbages do well on such land. The calcareous kinds, not too rich in clay and not too poor in sand and humus, give good returns. Those poor in humus are still suited for oats.
		Intermediate	,, 50	0	0·5 to 1·5	,,	
		Rich	,, 50	0	1·5 to 5·0	,,	
	With Lime...	Poor	Above 50	0.5 to 5 0	0·0 to 0·5	,,	
		Intermediate	,, 50	0·5 to 5·0	0·5 to 1·5	,,	
		Rich	,, 50	0·5 to 5·0	1·5 to 5·0	,,	
2. *Loamy Soils.* Not more than 50 nor less than 30 per cent. of Clay. Not more than 5 per cent. of Lime	Without Lime	Poor	30 to 50	0	0·0 to 0 5	,,	(*Wheat Land*) Wheat, barley, gram, jowar, cotton, arahar, maize, beans and cauliflower are the most appropriate crops for this class of land.
		Intermediate	30 to 50	0	0·5 to 1·5	,,	
		Rich	30 to 50	0	1 5 to 5 0	,,	
	With Lime...	Poor	30 to 50	0·5 to 5·0	0·0 to 0·5	,,	
		Intermediate	30 to 50	0·5 to 5 0	0·5 to 1 5	,,	
		Rich	30 to 50	0·5 to 5·0	1·5 to 5 0	,,	

Names of the different Description of Soils.			Proportions of Ingredients in every 100 Parts.				Agricultural Designation and General Relations with reference to their Produce.
Classes.	Orders.	Species.	Clay.	Lime.	Humus.	Sand.	——
3. *Sandy Loams.* Not more than 30 nor less than 20 per cent. of Clay. Not more than 5 per cent of Lime	Without Lime	Poor	20 to 30	0	0·0 to 0·5	The Remainder	(*Aus and potato land.*) *Bajra, Kalai, aus* paddy Barley with gram, *jowar*, mustard with wheat, and other *rabi* crops. Potatoes, turnips and other roots thrive wellin lands with lime.
		Intermediate	20 to 30	0	0 5 to 1·5		
		Rich	20 to 30	0	1·5 to 5·0	,,	
	With Lime...	Poor	20 to 30	0 5 to 5 0	0·0 to 0 5	,,	
		Intermediate	20 to 30	0·5 to 5·0	0·5 to 1·5	,,	
		Rich	20 to 30	0·5 to 5·0	1·5 to 5·0	,,	
4. *Loamy Sands.* Not more than 20 nor less than 10 per cent. of Clay. Less than 5 per cent. of Lime.....	Without Lime	Poor	10 to 20	0	0 0 to 0 5	,,	(*Mustard and Kalai land.*) Suitable for growing *kalai*, mustard, *sorguja*, cucurbitaceous vegetables, barley if rich in humus, and jowar. Indigo and buck-wheat in lands with lime. Barley and buck-wheat thrive well in those rich in humus.
		Intermediate	10 to 20	0	0 5 to 1 5	,,	
		Rich	10 to 20	0	1·5 to 5·0	,,	
	With Lime...	Poor	10 to 20	0·5 to 5·0	0·0 to 0·5	,,	
		Intermediate	10 to 20	0·5 to 5·0	0·5 to 1·5	,,	
		Rich	10 to 20	0·5 to 5·0	1 5 to 5·0	,,	
5. *Sandy Soils.* Not more than 10 per cent. of Clay. Less than 5 per cent. of Lime.....	Without Lime	Poor	0 to 10	0	0·0 to 0·5	,,	(*Millet land.*) *Bajra* with *til*, *kalai* or *mung* also barley with mustard and wheat. Of less value; often cultivated only every third year, and the poor lands not at all. Those containing humus and lime are chiefly fit for buck-wheat, oats, hemp, tobacco, potatoes, millets and maize.
		Intermediate	0 to 10	0	0 5 to 1·5	,,	
		Rich	0 to 10	0	1 5 to 5 0	,,	
	With Lime ..	Poor	0 to 10	0·5 to 5·0	0 0 to 0·5	,,	
		Intermediate	0 to 10	0·5 to 5·0	0 5 to 1·5	,,	
		Rich	0 to 10	0·5 to 5·0	1·5 to 5 0	,,	

Schubler's Classification and Nomenclature of Soils—(*continued*).

Names of the different Description of Soils.			Proportions of Ingredients in every 100 Parts.				Agricultural Designation and General Relations with reference to their Produce.
Classes.	Orders.	Species.	Clay.	Lime.	Humus.	Sand.	———
6. *Marly Soils.* (More than 5 but not more than 20 per cent. of Lime).....	Argillaceous	Poor	Above 50	5 to 20	0·0 to 0·5	The Remainder	*(Paddy and arahar land.)* Land suited for paddy, arahar, wheat and pulses.
		Intermediate	,, 50	5 to 20	0·5 to 1·5	,,	
		Rich	,, 50	5 to 20	1·5 to 5·0	,,	
	Loamy	Poor	30 to 50	5 to 20	0·0 to 0·5	,,	*(Pulse land.)* Wheat, potatoes, barley and pulses.
		Intermediate	30 to 50	5 to 20	0·5 to 1·5	,,	
		Rich	30 to 50	5 to 20	1·5 to 5·0	,,	
	Belonging to the Sandy Loams.....	Poor	20 to 30	5 to 20	0·0 to 0·5	,,	*(Oat land.)* Barley, oats, gram and maize.
		Intermediate	20 to 30	5 to 20	0·5 to 1·5	,,	
		Rich	20 to 30	5 to 20	1·5 to 5·0	,,	
	Belonging to the Loamy Sands	Poor —	10 to 20	5 to 20	0·0 to 0·5	,,	*(Jowar and bajra land.)* Oats, jowar, pulses and bajra.
		Intermediate	10 to 20	5 to 20	0·5 to 1·5	,,	
		Rich	10 to 20	5 to 20	1·5 to 5·0	,,	
	Humus	Clayey	Above 50	5 to 20	Above 5·0	,,	*(Corn land.)* The humus and argillaceous marly soils are amongst the best that exist.
		Loamy	30 to 50	5 to 20	,, 5·0	,,	
		Sandy	20 to 30	5 to 20	,, 5·0	,,	

Names of the different Descriptions of Soils.			Proportions of Ingredients in every 100 Parts.				Agricultural Designation and General Relations with reference to their Produce.
Classes.	Orders.	Species.	Clay.	Lime.	Humus	Sand.	——
7. *Calcareous Soils.* (Containing more than 20 per cent. of Lime)	Argillaceous	Poor	Above 50	Above 20	0·0 to 0·5	The Remainder	*(Pulse land.)* The argillaceous soils often approach in value to the argillaceous marls; the remaining orders of both these classes equally correspond one with the other; to the most valuable belongs, as in the case of marly soils, the humus. Those wanting in humus require much manure. Those rich in clay are well suited for wheat. Oats, and lucerne thrive in them. Their value is much decreased by containing an excess of lime.
		Intermediate	,, 50	,, 20	0·5 to 1·5		
		Rich	,, 50	,, 20	1·5 to 5·0	,,	
	Loamy	Poor	30 to 50	,, 20	0·0 to 1·5	,,	
		Intermediate	30 to 50	,, 20	0·5 to 1·5	,,	
		Rich	30 to 50	,, 20	1·5 to 5·0	,,	
	Belonging to the Sandy Loams	Poor	20 to 30	,, 20	0·0 to 0·5	,,	
		Intermediate	20 to 30	,, 20	0·5 to 1·5	,,	
		Rich	20 to 30	,, 20	1·5 to 5·0	,,	
	Belonging to the Loamy Sands	Poor	10 to 20	,, 20	0·0 to 0·5	,,	
		Intermediate	10 to 20	,, 20	0·5 to 1·5	,,	
		Rich	10 to 20	,, 20	1·5 to 5·0	,,	
	Sandy	Poor	0 to 10	,, 20	0·0 to 0·5	Any portion less than 80 per cent.	
		Intermediate	0 to 10	,, 20	0·5 to 1·5		
		Rich	0 to 10	,, 20	1·5 to 5·0		
	Pure	Poor	0	,, 99	0·0 to 0·5	None.	
		Intermediate	0	,, 98	0·5 to 1·5	,,	
		Rich	0	,, 94	1·5 to 5·0	,,	
	Humus	Clayey.....	Above 50	,, 20	Above 5·0	The Remainder	
		Loamy.....	30 to 50	,, 20	,, 5·0		
		Sandy	20 to 50	,, 20	,, 5·0	,,	

Schubler's Classification and Nomenclature of Soils—*(continued.)*

Names of the different Descriptions of Soils.			Proportions of Ingredients in every 100 Parts.				Agricultural Designation and General Relations with reference to their Produce.
Classes.	Orders.	Species.	Clay.	Lime.	Humus.	Sand.	——
8. *Humus Soils.* (Containing more than 5 per cent. of Humus)	Soluble Mild Humus ...	Clayey	Above 50	With or	Above 5·0	The	*(Land for oil seeds and vegetables.)* The value of these soils is greatly augmented by admixture with lime. Those which contain lime and clay are suited for wheat, barley, cucurbitaceous vegetables and oleagenous plants; the loamy and sandy are especially adapted for oats, and in most places for wheat. The peaty and acid humus may be made fruitful by admixture with lime, sand, and clay.
		Loamy	30 to 50	without	,, 5·0	Remainder	
		Sandy	20 to 30	Lime.	,, 5·0	,,	
	Insoluble Carbonized or Acid Humus.	Clayey	Above 50	With or	,, 5·0	,,	
		Loamy	30 to 50	without	,, 5·0	,,	
		Sandy	20 to 30	Lime.	,, 5·0	,,	
	Insoluble Fibrous Vegetable matter.	Bog and Peat Earth	With	Lime.	,, 5·0	,,	
			Without	Lime.	,, 5·0	,,	

63. The fertility of soils depends mainly on the presence in sufficient quantities of four essential constituents of plant food, *viz.* Nitrogen, Phosphoric acid, potash, and lime. In fact, lime and potash being almost invariably present in sufficient quantities, the excess or deficiency of Nitrogen and Phosphoric acid are mainly looked to in judging of the chemical character of soils. If a soil contains ·1 to ·5% of Nitrogen and ·08 to ·5 of Phosphoric acid, it may be classed as a fertile soil. Soils containing 1% of potash or lime (the latter not as insoluble silicate but as carbonate) are to be considered quite rich in these substances. A sample of dry soil showing ·1 of Nitrogen, phosphoric acid and potash would yield out of a depth of 9 inches, two to three thousand pounds of each of these constituents, per acre; but no crop ordinarily takes up more than 50 to 60 lbs. per acre of these substances. So that properly tilled a soil even left without manure would raise hundreds of crops. A soil containing ·2% of N. (calculated as NH_3), ·2% of P_2O_5 and ·5% of potash, and weighing when perfectly dry 1,600,000 lbs. per acre to a depth of 5 inches, is cap able of affording 3,200 lbs. of N. (calculated as NH_3), 3,200 lbs. of P_2O_5 and 8,000 lbs. of Potash. A good crop of 20 maunds of wheat and 30 maunds of wheat straw per acre would not require more than 40lbs. of N., 20lbs. of P_2O_5 and 26lbs. of K_2O. The object of manuring is to give a larger quantity of readily available plant food to growing crops and to help in dissolving the plant food of the soil and thus augmenting its quantity. A judiciously manured soil, also forest and pasture land, may go on getting more and more fertile. So few pounds of P_2O_5, K_2O,N, and CaO are taken up ordinarily by crops, that it is easy to more than recoup these by the use of proper manures. To ascertain however whether a particular soil needs the addition of K_2O,P_2O_5, N, or CaO in the form of manure, or if it is already sufficiently rich in this or that constituent and it will be superfluous to use one or another of the manures, it is not absolutely necessary to have recourse to chemical an-

alysis. A ten plot experiment may be made after Ville's method to understand the chemical character of a particular soil. There should be ten equal plots manured in the following way :—

No. 1. Sodium nitrate ($Na\ NO_3$), 220lbs. or Ammonium chloride ($NH_4\ Cl$), 140lbs. *i.e.* the quantity containing 36lbs. of N, should be applied per acre.*

No. 2. Unmanured plot.

„ 3. Sodium phosphate ($Na_2\ HPO_4$), 44lbs., *i.e.* the quantity containing 22lbs. of P_2O_5 should be applied per acre.*

„ 4. Unmanured plot.

„ 5. Quick-lime, CaO, 40lbs. should be applied per acre after slaking.

„ 6. Unmanured plot.

„ 7. Potassium Chloride (KCl), 50lbs. *i.e.* the quantity containing 32lbs. of K_2O should be applied per acre.*

No. 8. Unmanured plot.

No. 9 and 10 unmanured plots.

64. The plots need not be more than a few yards in length and width. They should be sown very thin with a mixed crop of *arahar* and maize or some other cereal and pulse crop together. The effect of lime and potash will be chiefly manifest on the pulse crop and that of N and P_2O_5 and also K_2O on the cereal crop. The same quality and the same number of seeds should be sown in each plot at similar distances and the same treatment given to all. The crops must be protected from parasites and pests, from

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* (1) $Na\ NO_3 = 23 + 14 + 48 = 85$; 14 : 36 :: 85 : x, x = about 219lbs. or say 220lbs.

(2) $N\ H_4\ Cl = 14 + 4 + 35{\cdot}5 = 53{\cdot}5$; 14 : 36 :: 53·5 : x, $x = 137\frac{1}{2}$lbs. or say 140lbs.

(3) $Na_3HPO_4 = 46 + 1 + 31 + 64 = 142$; $P_2O_5 = 62 + 80 = 142$; $2 \times 144 = 288$; 142 : 22 :: 284 : x ; $x = 44{\cdot}6$

(4) $KCl = 39 + 35{\cdot}5 = 74{\cdot}5$; $2 \times 74{\cdot}5 = 149$; $K_2O = 78 + 16 = 94$; 94 : 32 :: 149 : x ∴ x = about 50lbs.

drought and from waterlogging. The weight of grain and straw of the cereal and also of the leguminous crop should be noted. If the $NaNo_3$ plot shows special increase in the case of the cereal but not so in the case of the pulse crop the soil should be considered rather poor in nitrogen, especially if the yield of the cereal in the unmanured plots is found to be invariably less than that of the plot manured wirh $NaNo_3$.

If the Sodium phosphate does not show any benefit, the soil should be considered rich in phosphates.

If the plot manured with CaO shows better yield especially in the case of the pulse crop as compared to yield from unmanured plots, the land should be considered deficient in lime.

If the potassium -chloride plot shows no benefit in either case the land should be considered rich in potash.

If the cereal is benefited chiefly in the weight of the straw by the $NaNo_3$ the soil should be considered poor in N. If the Sodium phosphate plot shows better yield of grain in the case of the cereal, the soil should be considered wanting in phosphoric acid.

65. Na and Cl should be chosen as these elements are not so essential to plant life and do not affect the yield. The object of having buffer plots without manure, is to keep the effects of the different manures quite distinct. The plots should be protected from heavy rain or the experiment conducted in the Rabi season, lest there should be overflowing from one plot to the other. Watering should be done gently and care should be taken that there is no mixing up of soils, weeds, and crops of different plots. This ten-plot experiment is recommended for practical purposes in judging of the chemical value of soils. It will not give absolutely correct ideas as to the potentiality of a soil, but it will give a very fair idea of the available plant foods. If the plots are quite detached one unmanured plot will be found sufficient and in that case it will be a five-plot experiment. As experiments

should be always conducted in duplicate, two such series of five plots will also make a ten-plot experiment.

66. If none of the applications prove of any use, *i e.* if the yield of the cereal and of the pulse crop are about the same in all the manured and unmanured plots, the soil must be considered extremely rich in all available plant foods; and if notwithstanding all these applications one does not get any yield or very poor yield of pulses and cereals, the soil should be considered barren or very nearly so, that is (1) containing an excess of some salt, or (2) deficiency of some essential constituent, or (3) containing some poisonous substance.

67. Another method of carrying out this experiment is to apply a mixture of all the four manures (which is called Ville's Normal Manure) to one plot, the same without lime to the next, the same without potash to a third, the same without phosphoric acid to a fourth, and the same without nitrogen to a fifth. This is called Ville's Five Plot Experiment. There should however be unmanured plots for comparison and the more the number of such plots the better.

CHAPTER VI.

CHEMICAL CLASSIFICATION OF INDIAN SOILS.

"THE four main types of soil" says Dr. Leather, "which occupy by far the greater part of the Indian cultivated area, are (1) the Indo-Gangetic alluvium, (2) the black cotton-soil or *regur*, (3) the red soils lying on the metamorphic rocks of Madras and (4) the laterite soil which are met with in many parts of India." (5) Stretches of alluvium which are situated at the mouths of the Mahanadi, Godaveri,

and other rivers, which bear no comparison to the Indo-Gangetic alluvium. (6) The soil covering the Dharwar (C. P.) rocks are also quite different from the red soils of the metamorphic rocks of the Madras Presidency. Soils of other kinds also occur in smaller patches, but the main types of Indian soils are four.

69. The soils of the Indo-Gangetic alluvium are generally of fine texture, containing no pebbles, and the only particles larger than sand to be met with in the alluvium consist of *Kankar*, deposited within a few feet of the surface. The character varies within certain limits. In most places the alluvium is yellow loam. In some places it is sandy, and in others clayey. The clay is generally bluish grey. Occasionally also sand *düns* or hills have been formed by the wind.

70. The following tables furnish the analyses by Dr. Leather of the principal Indo-Gangetic alluvium soils.

I. Sandy soil from Ison sand belt near Cawnpore.—

Insoluble Silicates and Sand	91·72 °/₀
Fe_2O_3	2·36 „
Al_2O_3	2·92 „
CaO	·35 „
MgO	·78 „
K_2O	·33 „
Na_2O	·08 „
P_2O_5	·08 „
SO_3	·04 „
CO_2	·27 „
* Organic matter and combined water	1·07 „
	100·00

* ·027°/₀ of Nitrogen.

II. Sandy loams :—

	From Ison Ganges Doab.	From Burdwan Experimental Farm.
Insoluble Silicates and Sand ...	88·08 %	84·31 %
Fe_2O_3	3·10 „	5·58 „
Al_2O_3	4·38 „	6·09 „
MnO	Nil. „	·12 „
CaO	·47 „	·28 „
MgO	·32 „	·66 „
K_2O	·64 „	·56 „
Na_2O	·09 „	
P_2O_5	·08 „	·04 „
SO_3	·05 „	·02 „
CO_2	·37 „	·21 „
Organic matter and combined water...	*2·42 „	†2·13 „
	100 00	100 00

* N = ·081 per cent. † N = ·042 per cent.

III. Loamy soils :—

	Cawnpore.	Patna.	Dumraon Experimental Farm.
Insoluble Silicates and Sand ...	84·84%	82·96%	86 82%
Fe_2O_3	4·52 „	4·59 „	4·09 „
Al_2O_3	5·30 „	5·11 „	4·57 „
MnO	Nil „	·11 „	·10 „
CaO	·91 „	1·78 „	·30 „
MgO	·52 „	1·53 „	·76 „
K_2O	·16 „	·66 „	·48 „
Na_2O	·03 „	·30 „	
P_2O_5	·10 „	·13 „	·08 „
SO_3	Nil „	Nil „	Nil „
Co_2	·71 „	1·10 „	·01 „
Org. matter and combined water	*2·91 „	†1·73 „	‡2·79 „
	100·00	100·00	100·00

* N = ·046 per cent. † ·045 per cent. ‡ ·049 per cent.

IV. Clay soils :—

	(I) Bahr, Patna.	(II) Dumraon Farm.	(III) Sibpur Farm.
Insoluble Silicates and Sand ...	72·64 %	80·90 %	73·58 %
Fe_2O_3	7·58 „	6·12 „	6·36 „
Al_2O_3	9·89 „	6·50 „	7·93 „
MnO	·14 „	·14 „	·11 „
CaO	1·01 „	2·07 „	1·52 „
MgO	1·64 „	1·17 „	1·61 „
K_2O ... ... / Na_2O	·82 „	·73 „	·64 „
P_2O_5	·07 „	·08 „	·11 „
SO_3	Nil „	Nil „	·03 „
CO_2	·28 „	·05 „	1·35 „
Organic matter & combined water	*5·93 „	†2·24 „	‡6·76 „
	100·00	100·00	100·00

* N = ·051 per cent. † ·041 per cent ‡ ·065 per cent.

71. Two other samples of Sibpur Farm Soil analysed by Dr. Leather gave the following results :—

Insoluble Silicates and Sand ...	78·95	72·88
Soluble Silicates ...	·03	·28
Iron (Fe_2O_3) ...	4·73	6·28
Alumina (Al_2O_3) ...	4·47	7·96
Manganese (MnO) ...	·11	·12
Lime (Cao) ...	2·07	2·03
Magnesia (MgO) ...	2·00	2·14
Alkalis (soda and potash) ...	·08	1·79
Sulphuric acid (SO_3) ...	Nil	Nil
Phosphoric acid (P_2O_5) ...	·11	·12
Carbonic acid (Co_2) ...	3·82	3·95
Organic matter and combined water ...	3·63	2·45
	100·00	100·00
Nitrogen (total) ...	·063	·065

The above three analyses give some idea of the variableness of composition of the soil of Sibpur Farm, which is chiefly in lime and the alkalis.

V. Calcareous soil from Pratapgarh (Oudh) :—

Insoluble Silicates and Sand	57·52 %
Fe_2O_3	3·23 „
Al_2O_3	3·39 „
MnO	Nil „
CaO	14·54 „
MgO	1·86 „
K_2O	·44 „
Na_2O	·02 „
P_2O_5	·18 „
SO_3	·08 „
CO_2	11·42 „
Organic matter and combined water	*7 32 „
	100·00

* N = ·180%

72. Though calcareous soils are rare in India, beds of *kankar* commonly underlie the Indo-Gangetic alluvium, the black cotton soil and other soils. The surface soil of the alluvium is usually free from *kankar*, except where there is an outcrop of the bed of *kankar*. In the black cotton soil, the *kankar* occurs in beds as well as mixed up with the soil. Some of the *regur* soils contain as much as 10 % of calcium carbonate. The soil of the Sibpur farm is rich in calcium carbonate (about 3 per cent.). The amount of P_2O_5 also in Indo-Gangetic alluvial soils is usually more than in other Indian soils. The amount of potash in the samples examined is sufficient. The amount of N and organic matter in Indo-Gangetic alluvium is usually low. The amount of iron and allumina in the Indo-Gangetic alluvium is usually higher than in European loams and clays. The sandy soils contain about 2½% of these. The proportion is higher in loams, while in clays it is 6 to 8%. The proportion of magnesia which

varies from ½ % (in sandy soils) to 1½% in clays, is also a little higher than in similar English soils. Sulphates are practically absent from the *regur*, the red-soils of Madras and the laterite soils, but alluvial soils sometimes contain a small amount.

73. We next come to the black cotton soils or *regurs*. Their composition is not very variable *in soluble silicates and sand* (65 to 75%.) Few samples contain less than 65% or more than 75%. Fe_2O_3,—5½ to 8½%, rarely more than 8½ and less than 5½%. Al_2O_3,—8·5 to 11 percent, rarely more or less. Madras *regur* soils contain more alumina than iron (by 1 to 2%) and C. P. *regur* soils more iron than alumina. *Manganese*, ·12 to ·25%, sometimes, but very rarely, more or less. CaO,—as carbonate and also partly as silicate. In those samples in which there is 2% or more of lime, the greater part is carbonate, where it is less than 2% it occurs chiefly as silicate. Regurs usually contain 2 up to 4 or 5%. MgO,—1·3 to 3·1%, usually 2 to 2½%, which is rather a high proportion. *Alkalis*,—·15 to 2·44%. The potash is unusually high in *regur* soils. P_2O_5,—usually small. Below ·1% is the rule; occasionally goes up to ·2% CO_2,—combined with $CaCO_3$, chiefly in small nodules of *kankar*, is very variable in proportion. SO_3,—hardly appreciable. *Nitrogen*,—·012 to ·050%. *Regurs* are poor in N. like most other Indian soils. Organic matter and combined water occur in very high proportion, but it is chiefly combined water and not organic matter. In heating the *regur* changes colour from black to dark brown and contracts very much in volume. This is due to the loss of the water of hydration from hydrated ferric oxide or alumina in which substances the *regur* is specially rich. The regur is rather poor in organic matter and nitrogen and its richness is chiefly due to its friability and its power for retaining moisture. Indeed the outturn of crops from unmanured land at the Nagpur Farm is lower than from similar loamy soil in the Gangetic alluvium. At any rate, it is Dr. Leather's opinion,

that it is a common mistake to suppose that the black cotton soil of Southern India is very rich and it is only richer than the surrounding gravelly red and brown soils. If *regur* be boiled with concentrated sulphuric acid for several hours, the insoluble residue (*i. e.*, the silicates) is very dark brown. Other soils similarly treated usually give a white residue. The black colouring matter of the silicates digested with strong sulphuric acid if due to organic matter would disappear under this treatment, and it must be concluded that the blackness of the silicates in *regur* is due to some dark coloured mineral and not to organic matter.

74. We next come to the *brown alluvial soils of Madras* The loamy ones contain high proportions of iron and alumina. The amount of lime is small and the amount of magnesia high. They are as a rule rich in potash but not in P_2O_5 and N. These are believed to be very fertile soils, but the analyses do not show them to be any more fertile than the Indo-Gangetic alluvium.

75. *The Red Soils of Madras.*—The amount of lime in these is small or only moderate, that of magnesia also is not high, while that of phosphoric acid is uniformly low. The proportion of potash is indifferently high or low, that of ferric oxide and alumina rather high. The proportion of Nitrogen and of organic matter is low. They resemble laterite soils in composition, the main difference being in the proportion of P_2O_5. Some laterite soils have a high proportion of this constituent, and others very low, whilst the Madras red soils of Coimbatore, Madura, Karnool, Trichinapoly and Kistna are all uniformly poor in P_2O_5, the extreme variation in the samples analysed by Dr. Leather being between ·04 and ·11 per cent.

76. *Laterite Soils*—With these and with alluvium soils we have chiefly to do in Bengal, and we might learn the actual figures given by Dr. Leather in connection with the analyses of some of the laterite soils of Hazaribagh, Lohardaga, Singhbhum and Manbhum.

Table showing the composition of Laterite soils of Bengal.

	Hazaribagh.				Lohardaga.		Singbhum.	Manbhum.			
	Surface soil.		Subsoil		Surface soil.	Subsoil.	Surface soil.	Surface soil. (overlying laterite rocks)			
	A	B	A	B				A	B	C	D
Sand ...	78·62	80·46	74·84	76·96	29·67	33·66	59·06	90·07	85·50	90·29	90·34
Fe_2O_3 ...	6·35	6·12	6·96	6·40	48·71	42·08	49·92	4·27	5·68	2·90	3·17
Al_2O_3 ...	8·98	7·19	11·57	11·31	8·81	13·89	7·27	2·59	4·00	4·49	2·95
MnO ...	·39	·50	·28	·33	·07	·06	·48	·09	·11	·09	·06
CaO ...	1·50	1·72	·96	·94	·38	·45	·28	·14	·47	·14	·38
MgO ...	·66	·38	·81	·51	·21	·20	·33	·31	·60	·28	·36
K_2O ...	·43	·38	·07	·44	·10	·27	.27	·14	·40	·19	·25
Na_2O ...	·21	·32			·04						
P_2O_5 ...	Trace	Trace	Trace	·04	·64	·62	·08	.13	·30	·04	·06
So_3 ...	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
CO_2 ...	·12	·12	·08	0·5	·06	·12	·16	·28	·06	·05	·38
Org. mat. &c.	2·74	2.81	3·80	3·02	1·31	9·01	5·43	1·98	2·88	1·53	2·05
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
N.	·039	·030	·032	·026	·010	·010	·024	·016	·032	·031	·036

77. *General remarks about Indian Soils. Iron* usually occurs in larger proportion than in English soils,—in the Indo-Gangetic alluvium 2 to 7 per cent., in the *regur* 4 to 11½ per cent., in the Madras red soils 3½ to 10 per cent., in true laterite soils 6 to 48 per cent. and in Madras alluviums 5 to 17 per cent. *Alumina :* The proportion of this substance is also high in Indian soils. In the Indo-Gangetic alluvium 3 to 10%; *regurs* 6 to 14; Red soils 1½ to 15½; laterite 7½ to 14; Madras alluvium 6 to 15 in loams, but less in sandy soils. Coffee soils of the Madras Presidency contain as much as 17 to 20 per cent. of this constituent.

MnO : Widely distributed in Indian soils, but the proportion is small though quite enough for the requirement of plants. Alluvial soils; ·11 to ·30; *regurs*—·1 to ·26; Red soils—·07 to ·20; laterite soils ·06 to ·50; Madras alluvium ·03 to ·26.

Lime : Usually as silicate more than as carbonate; calculated as Oxide, Gangetic alluvium—.3 to 2%; *regur* 1 to 7·7%; Madras red soils, laterites and Madras alluvium less than 1%.

An English farmer usually aims at maintaining a fair proportion of lime in his soil, about 1%. This is for the purpose of having a free basic matter to combine with the organic acids as soon as they are formed from the humus and they are continuously being formed. The proportion of humus, however, in English soils is higher and so it is doubtful if those Indian soils which contain less than 1% of lime really need to be brought up to the standard aimed at by English farmers. Lime as a plant food is required only in a very minute proportion. The laterite soils which are particularly poor in organic matter are also poor in lime. They would not be benefited by any addition of mere lime. On the whole, it may be said Indian soils are rich in lime.

MgO—More abundant than in English soils: Gangetic alluvium usually over 1 per cent.; *regur* 1 to 3 per cent. Red soils ¾ per cent. Laterite soils less.

K_2O—Not deficient, though not abundant.

P_2O_5—·12 to ·13% is considered a good average in England. Of no class of Indian soils examined except the soils from Meerut district and the coffee soils of Sheveroy hills, Madras, can it be said that it comes up to the English standard. Dr. Leather is obliged to admit that Dr. Voelcker's opinion that phosphoric acid is "more abundantly distributed in Indian than in English soils" is erroneous. Some of the soils of the Meerut district only analysed by Dr. Leather contained as much as ½ a per cent. of P_2O_5.

78. But although the *proportion* of total phosphoric acid in Indian soils is decidedly meagre, the proportion of *available* phosphoric acid is not usually deficient, and it is the available phosphoric acid that immediately affects the question of fertility or of produce. The application of bones has not been attended with any very beneficial results in India, except in a few isolated cases. This shows that the proportion of available phosphoric acid is probably high. Dr. Bernard Dyer of London has discovered an empirical method of finding out the available phosphoric acid and potash in soils. This consists in submitting soils to the action of 1% solution of Citric acid for 7 days and determining the proportion of P_2O_5 and K_2O in the solution. Dr. Dyer aimed at demonstrating whether the results of such treatment would correspond with the known fertility of some of the standard soils of the Rothamsted Experimental Farm. The result of the research showed conclusively that a very close correspondence exists between the amount of phosphates and potash thus dissolved from the soils and their known fertility in the matter of phosphates and potash. Dr. Dyer concluded from his research that "when a soil is found to contain as little as about ·01 per cent. of phosphoric acid soluble in a 1% solution of Citric acid, it would be justifiable to assume that it stands in immediate need of phosphatic manure." Dr. Leather applying Dr. Dyer's method in a few cases showed that even

in typical alluvial and *regur* soils the proportion of available phosphates is usually over ·01 per cent. Only in two cases he found the proportion less than this. The soils of the Cawnpore, Dumraon and Nagpur Experimental Farms contain ·05 to ·09 per cent. of total phosphoric acid, but soil from only one plot in the case of the Nagpur and one plot in the case of Dumraon farm showed the proportion of available phosphates to be less than ·01 per cent. About $\frac{1}{3}$rd or $\frac{1}{4}$th of the total phosphates is usually in an available form in Indian soils, while in English unmanured soils the proportion of available phosphates is about $\frac{1}{10}$th, and in manured soils, higher,—about $\frac{1}{4}$th.

79. SO_3.—Like phosphoric acid when sulphuric acid is present in a soil, it always exists in combination with some one or other of the metallic oxides, with which it forms sulphates. There is usually no simple means of determining with which base it is associated, and for purposes of ready expression, its amount is calculated in the form of the anhydride. The majority of Indian soils contain remarkably little sulphate,—in no case as much as ·1 per cent. An exception occurs in the case of *usar* soils which are impregnated with sodium sulphate and sodium carbonate salts.

80. CO_2.—The determination of this is not of much consequence. It usually exists in proportions not sufficient to combine with the lime present and it may therefore be assumed that the CO_2 is present wholly or mainly in combination with lime.

81. *Organic matter and N*.—As a rule, Indian soils contain little organic matter. The loss by heating is often due chiefly to loss of combined water, and a knowledge of the loss by combustion of a soil does not serve as a means of even approximately determining the amount of that most valuable constituent, humus. The loss by combustion occurs chiefly where the proportions of iron and alumina are great. The coffee soils of Sheveroys are rich in N and so are some soils

of Pratapgarh. Speaking generally Indian soils contain less than ·1 per cent. of N. The Gangetic alluvium contains only ·05 per cent. (a little more or a little less). In the Madras alluvium the proportion is the same or a little higher. The *Regurs* and Red soils usually contain less than ·05 per cent. Laterite soils contain only about ·03 per cent. But soils that have had the opportunity of accumulating N, whether in old fallows or in forests, contain a higher proportion.

CHAPTER VII.

PHYSICAL PROPERTIES OF SOILS.

WEIGHT.—The specific weight of soil as it naturally occurs, *i.e.* the weight of natural soil as compared to that of distilled water varies from 1 to 2. Some peat soils have less specific weight than 1. The floating vegetable gardens of Kashmir consist of light peat soil of this kind. The absolute weight of soils varies from 50 to 120lbs. per cubic foot. A cubic foot of distilled water weighing 62·5lbs. A cubic foot of rich garden mould weighs about 70lbs. of ordinary arable land 80 to 90lbs.; of dry sand 110lbs. The weight of an acre of soil to the depth of 1 foot varies from 1 to 5 million lbs.; of dry sand, about 4,800,000lbs.; of loam consisting of half clay and half sand 4,200,000lbs.; of ordinary arable soil 3,800,000 to 3,900,000lbs.; of stiff clay, 3,250,000lbs.; of garden mould 3,000,000lbs.. An acre of peat to the depth of 1 foot weighs from 1 to 2 million lbs.. A soil when perfectly dry was found to weigh 3,137,000lbs.. The same soil when wet was found to weigh 4 million lbs.. It should be remembered 1 inch of rainfall increases the weight of an acre of soil to a depth of 1 foot by about 100 tons (2,24,000lbs.). In agricultural language, a soil is said to be heavy which offers

considerable resistance to the plough. Sandy soils which actually weigh heavier than other soils are called *light soils* because they offer least resistance to the plough. A stiff clay soil which is said to be very heavy becomes lighter *i.e.* less resistant to the plough, after there is a shower of rain, though the rain actually adds to the weight of the soil. The specific gravity of soils not as they actually occur but after they are absolutely dry, varies from 2·5 to 2·8. The specific gravity of soils very rich in organic matter is sometimes less than 2. The specific gravity of quartz is 2·65.

83. *Porosity.*—The fineness of division of the particles of soil has great influence on vegetation. Food of plants must pass into solution before it can be assimilated. The rapidity with which dissolving action can take place is in direct ratio to the surface. The finer the particles the greater the surface and more the space the growing roots have for their development and spread. But when the particles are too fine, the soil becomes too compact for roots to penetrate, and it cracks in drying which also interferes with the spread of roots. Up to a certain limit therefore fineness of division of the particles of soil is desirable. The condition known as loamy is the best in respect of porosity.

84. *Retention of water.*—This capacity of soils depends mainly on the fineness of division of their particles. Humus or vegetable organic matter in the soil has the greatest capacity for retaining moisture, and clay has greater capacity in this respect than sand. Angular fragments have greater capacity than round fragments for retaining moisture. 100 parts of sand take up about 25 parts of water by weight and 49 parts by volume; clay, 40 parts by weight and 68 by volume; fine calcareous soil, 85 by weight and 80 by volume; humus 190 by weight and 93 by volume. Ordinary Agricultural soil takes up about 50% by weight of water. It will thus be seen that an inch of irrigation or rainfall at a time is quite enough to thoroughly soak it to a depth of 1 foot, and provision in the

matter of irrigation should be ordinarily made on this basis. Heat decreases this capacity for holding water. The porosity of soil though depending mainly on the fineness of its particles, also depends on looseness or fineness of tilth. Loose agricultural soil can hold 59% of water, while the same soil shaken down will hold only 45%, and pressed down only 40%.

85. *Capillarity.*—The capillary power of soils for drawing water up from below depends on their porosity. Clay possesses the greatest capillarity and sand and chalk the least. A column of fine clay wetted from the bottom will become wet to a height of 1 to 2 yards. Quartz sand similarly wetted becomes wet to a height of only ½ yd., and chalky or calcareous soil (*i.e.* soil made up of particles of pure calcium carbonate) to a still less height. The capillary action of soils in lump is less than that of the same soils when finely powdered or broken down. This is one of the many reasons why cultivation benefits crops. Capillary action takes 3 or 4 days before it reaches its final limit.

86. *Hygroscopic power.*—All porous bodies have the power of absorbing moisture from the atmosphere. The proportion of moisture absorbed depends (1) upon the surface exposed, and (2) on the nature of the substance. Organic substances, as a rule, are more hygroscopic than mineral substances. Wool, silk and hair are highly hygroscopic. Wool absorbs 19 to 20% of moisture from air at the freezing temperature. In buying and selling this must be borne in mind. Silk may contain 9 or 10% of latent moisture over and above the 11% of normal moisture, without one noticing it. In buying 100 maunds of silk it is quite possible to throw away Rs. 7,000 or Rs. 8,000 in buying superfluous water. Dry seasons should be chosen for buying these substances. Manuring soils with refuse from wool or silk factories or with hair, increase their absorbent power for moisture. Absorbent power varies very considerably in soils. Coarse quartz-sand absorbs

little or no water from air; calcareous sand very little; ordinary arable, clay and humus soils, more and more. Calcareous sand finely powdered absorbs 12 times as much aqueous vapour as in coarse state. The rapidity of absorption depends upon the proportion of moisture present in the air; but the total amount of water absorbed mainly depends on temperature, more being absorbed in low than in high temperature. Hence the necessity of dessicating the soil in uniformly high temperature for purposes of analysis. Sowing of seed for Rabi crops should be done in the evening after which the land should be harrowed and left in an open state for absorption of dew. In the morning rolling or laddering should be done so as to keep in the moisture absorbed at night.

87. *Evaporation.*—Soils becoming superficially dry in day time absorbs moisture at night. All soils exposed to air lose their moisture more or less rapidly,—sandy soils most rapidly, clay less rapidly, and humus soils least rapidly. Exposed to dry atmosphere at 19° C for 4 hours,—

Siliceous soil loses	88%	of moisture.
Calcareous sand	76 „	„
Pure clay	52 „	„
Clay soil	35 „	„
Chalk	28 „	„
Garden soil	24 „	„
Humus or peaty soil	20 „	„

88. *Coagulation.*—In fresh water, clay remains in suspension for a very long time, but in salt water it gets coagulated and deposited at the bottom. Hence formation of soils in the sea is facilitated. The addition of common salt or gypsum or of any soluble salt to a mixture of clay and fresh water would demonstrate the action the sea has in the formation of clay soils. The application of certain manures such as castor-cake or gypsum to clay-soils, is known to make it more friable.

89. *Shrinkage and expansion.*—Pure clay contracts 18%

in volume when it becomes wet, and strong clay soils may contract 8 to 10%. Light sandy soils with little humus undergo little or no change in volume when wet. Humus soils expand up to 15% when wet, and more in frost. Clay soil also expands in frost. This expansion often causes rupture of roots of crops growing on these soils. Clay soils in drying crack. These cracks also damage the roots of growing crops.

90. *Colour.*—The colour of the soil somewhat affects its temperature. Dark coloured bodies being more quickly heated than light coloured bodies, humus soils and dark basalt soils are warmer than lime-stone soils and sandy soils. If dark coloured shales are sprinkled over vineyards in cold countries, ripening takes place quicker. Smooth and white substances sprinkled over dark coloured soil would keep such soil comparatively cool. As we are more interested in keeping soils cool rather than warm, we might try the effect of scattering white chips of stone or chalk on dark coloured soils. For practical purposes the question of colour is not of much importance in a country where coolness is best secured by moisture which most soils are in need of at certain critical periods. The question of temperature of the soil, however, is of great importance, and we will treat of this subject in the next Chapter.

CHAPTER VIII.

METEOROLOGICAL CONDITIONS AFFECTING FARMING.

TEMPERATURE.—The mean temperature of the surface soil differs in different climates, but even in the same locality some soils are recognised as *cold* and others as *warm*. The heat of the soil is derived from three sources and it is dis-

tinguished accordingly as solar heat, terrestrial heat and chemical heat. The chemical heat derived from decaying organic matter especially in porous soils, is very considerable; but as this heat is evolved very slowly it has little perceptible effect on plant-life. Owing to the internal heat of the earth, there is very little change of temperature due to surface radiation, between day and night below a depth of 4 feet from the surface in warm countries. In cold countries, below a depth of 75 to 80 feet the temperature is constant, *i.e.* not affected by radiation at night and solar heat by day. The mean annual temperature of the surface soil is slightly over that of the air; but moist clay soils are colder than the atmosphere above them, as the continual evaporation going on from them renders a large amount of heat in them latent. Water ascending by capillary action from the subsoil and taking the place of that evaporated from the surface soil, keeps the surface soil always cold.

92. *Specific heat.*—The less the specific heat of the soil the more rapidly is it heated. The specific heat of soils compared to that of water varies from ·2 to ·5 for equal volumes and from ·16 to ·3 for equal weights. Sand has greater specific heat than clay. Actual capacity of soil for heat, however, is largely dependant on its capacity for water as water has 4 or 5 times the specific heat of soils. Quartz-sand becomes heated to the highest temperature, and white chalk soil to the least temperature under the same solar influence. The coolness of lime soils is therefore of great advantage in warm climates, and the advantage of *Kankar* beds can be viewed from this point also. Moist clay soils which are considered very objectionable from the temperature point of view in cold countries should from the same point of view be looked upon as highly advantageous for this climate.

93. *Radiation.*—Radiation also affects temperature. Smooth and polished surfaces which reflect heat most perfectly, absorb and radiate it least readily. The radiation from

moist soils at night is less quick, but on the whole such soils are colder and are called cold soils. Nocturnal radiation results in quicker formation of dew in the interstices of soils where water vapour accumulates in larger proportions than in the air.

94. *Retention of heat.*—Quick or slow cooling depends partly on specific heat but chiefly on fineness or largeness of particles of the soil, finely divided particles cooling more readily. Soils covered with gravels, cool more slowly than sandy soils. Sandy soils also retain heat longer than clay soils and these longer than humus soils. Water being a bad conductor of heat, wet soils differ little from one another in the absorption and retention of heat. A wet plot may be as much as 7°C higher in temperature early in the morning or 7°C lower in temperature at 3 or 4 P.M. in day time than a neighbouring dry plot. The physical effect of irrigation on soils in equalising temperature and keeping soils from getting too hot cannot be overrated in a climate like that of India. In England coldness of soils is avoided by drainage. Drainage for this purpose alone is not required in this climate.

95. *Evenness of temperature* and slow nocturnal radiation are very helpful to the growth of plants. Uniformity of temperature occurs in sea-side places the climate of which should be considered favourable to vegetation for this reason only. It should be noted however that cold is helpful for developing the germinating power of seed in the case of many agricultural crops of the temperate climate, and the difference of summer and winter is therefore beneficial. In sea-side places, high winds prove an obstacle to agricultural operations. From January to May the difference between the day and night temperatures is the greatest in the plains of Bengal, while in July and August it is the least. Vegetative processes are hampered therefore from January to May and highly facilitated in July and August. In Calcutta the nocturnal radiation in January amounts to 9·2° F. and in

July only 2·3°F. The maximum and minimum temperatures of Calcutta throughout the year will be found from the following table :—

	Maximum	Minimum
January	83°F.	52°F.
February	91°	54°
March	99°	64°
April	103°	69°
May	100°	69°
June	98°	73°
July	93°	76°
August	92°	75°
September	93°	75°
October	91°	68°
November	86°	57°
December	81°	52°

96 *The maximum and minimum* temperatures chiefly determine the crops that can be successfully grown at a certain locality. A temperature of over 90°F. is not suitable for growing wheat and a temperature of under 60°F. is not suitable for the growth of rice. A temperature of 32°F. *i.e.* frost, is unsuitable for the growth of all vegetation, though it does not kill deep-rooted crops and trees, the roots of which are securely lodged in warmer layers of soil. Evenness of temperature of the layers of soil in which the roots of plants are lodged is helpful to vegetation only when other conditions are equal.

97. The following table gives the temperature of the soil of Calcutta at the surface and at the depth of 3 feet :—

	Mean temperature at the surface	Mean temperature at a depth of 3 feet.
January	64·4°F.	72·5°F
February	71·2°	74·1°
March	82·7°	78·4°
April	91·3°	84·5°
May	90 4°	87·1°
June	87 5°	87·2°
July	86·2°	86·4°
August	85·9°	86 1°
September	86 0°	89·1
October	83·2°	85·2
November	73·3°	81·0°
December	64 8°	75·1°
Yearly mean temperature ...	80 6°	82·0°

98. *Inclination* or the angle at which the sun's rays strike the earth, influences the temperature of the soil. Where there is a sufficiency of moisture, more direct rays of the sun causing greater heat of the soil, only result in richer vegetation of the indigenous kinds. A southern slope in the N. Hemisphere is therefore desirable for moist climates; but a level soil helping retention of rain water on it is by far the best for all ordinary purposes, in most parts of India. In cold climates even radiation from walls is taken advantage of in increasing the heat of the neighbouring soil and in growing fruits on the walls to greater perfection.

99. *The Electrical influences* of various classes of soils on plant life in wet and in dry conditions, have not been studied sufficiently minutely to enable us to give definite information on the subject. But this is the subject which is being largely studied at present chiefly in France and Germany and important results are anticipated from this study. Electricity has been applied to plants in two ways,—(1) through the soil by means of wires buried about 2 inches deep and (2) by powerful arc-lights which act like strong sunlight, the light being also softened by amber globes. Under this continuous action crops have been matured in half the usual time, the light being kept burning the entire night. As soon as the seed is sown, the electric current is turned on by the underground wires. Germination takes place quicker and more freely and fully, and if the electric stimulation is kept up, growth goes on more vigorously. An increased yield of 50 per cent. over ordinary methods has been obtained by the application of electricity in this way. It has been shown by experiments conducted in Europe and in America that electricity can be applied to ordinary agricultural purposes on a large scale. Naturally electricity in the atmosphere is a potent agent in converting the free Nitrogen of the air into nitric acid which as nitrates is afterwards utilised by plants.

100. *Sunlight.*—Solar rays of different colours are known

to produce different effects on vegetation. An experiment was conducted in glass compartments in which glass of the following colours was used: ruby, brown-red, orange, yellow, cobalt-blue, and deep green. The young plant first broke the soil in the box covered with the orange glass and last under those covered by yellow, green and blue glasses. It was subsequently found that the effect of the yellow rays was such as to prevent the germination of the seed even although the rays only rested on the surface of the soil while the seed lay buried beneath; while, again, the blue light seemed to remarkably favour the process. Under the orange light the plants grew very tall, but then they had white stalks, and they refused to put forth any flowers. Under the yellow light it was remarkable that a number of little fungi or moulds sprang up and flourished luxuriantly while the plants themselves withered and died. Under the red light the plants only grew an inch or two high, had something of a reddish colour, and soon rotted and perished, although supplied with abundance of food in the soil in which they were placed. Under the green light the plants grew slowly but tolerably strong, yet none would flower, notwithstanding the greatest care and attention paid to them. The results under the blue glass were very different. The seed germinated a little less quickly than in the open air, but the plants became compact and healthy in their character, putting forth their flower-buds strongly and flowering in perfection. Under this light alone did the various processes go on with that vigour which is characteristic of vegetation in the open air. It is inferred that such would also probably be the case with plants grown under violet glasses.

101. *Rainfall.*—It cannot be said, that the causes that govern rainfall in India, are very well understood. Rainfall is regulated partly by the prevailing winds and partly by the contour of the country chiefly with reference to the position of the seas and the mountains. In the neighbourhood of high

mountains on the face turned towards the sea, the rainfall is generally heavy, as condensation of vapour takes place most readily on these mountains. A table-land surrounded by mountains receives very little rain, since the winds which reach it have already parted with their moisture in ascending the hill-sides. Differences of temperature in different regions of the globe stimulate currents of air, and when into a very hot and dry region a current of air flows from the sea or from cold and moist hill-tracts, cyclonic disturbances accompanied by rain follow. In February and March, when the sun is still southerly in direction, there remains a tendency for north winds to blow, though south winds are the rule, at this time. The south winds charged with vapour from the Bay get cooled down when they move up the sides of the Himalayas, and if at this time, a southern direction is given to this wind at the higher regions, they recede in their course, and the particles of condensed or congealed vapour come down in the form of rain or hail. If later on in their downward and southward march these receding winds come in contact with a strong well established current of wind from south to north west, a gale, or a cyclone, is the result. Thus in February and March we may have hail due to certain local currents and in April generally rain accompanied by north-westers, also due to local currents. But it is the continuous heat of April, May and June which tends to rarify the air and make the atmospheric pressure light, that establishes zones of low pressure, which take more or less a definite shape, and continuous currents of air laden with moisture thereafter flow into these zones, in definite directions. Thus in Bombay the monsoon current is from the South-west, *i. e.* the Arabian sea, while we have it from South-east, *i. e.* the South-west current from the Bay is deflected by the Chittagong and Assam hills which accounts for the easterly direction of the wind in Bengal during the monsoon. The establishment of these non-local currents of air, immediately precedes the

setting in of the monsoons. Under normal conditions they begin in Ceylon between the 14th and 20th of May, at the Andamans and Rangoon a few days later, and at the head of the Bay during the first or second week of June. To obtain telegraphic information regarding the monsoon currents from various stations in Southern India, from Ceylon and from the Andamans, is therefore of very great importance, specially at the time of transplanting paddy.

102. The *amount and distribution of rainfall* which a particular locality receives, usually determine its productiveness, especially in the tropics. In the Malabar coast of India and in parts of Assam the largest quantity of rainfall occurs and these are the most productive tracts in India. The regions of heavy rainfall, *i. e.* of 70 to 100 inches or more, are Assam, parts of Eastern Bengal, the Cis-Himalayan region of Northern Bengal and the Eastern and Western Ghauts.

103. *Elevation*, which mainly determines the amount of ammonia and nitric acid which come down by rain; *latitude* which determines temperature, and longitude which determines directions of wind, are all potent meteorological agencies influencing fertility. At low elevations a comparatively higher proportion of ammonia is obtained by means of rainfall, but somewhat less of nitric acid, the formation of which in the higher regions of the atmosphere is due to electrical action in the clouds. Elevation also is an evidence of the texture and composition of soils, also of temperature and humidity, when the elevation is above 1000 feet. Calcutta is about 21 feet above the sea-level; Dacca 35 feet; Sylhet 53 feet; Cuttack 80 feet; Chittagong 86 feet; Burdwan 99 feet; Durbhanga 166 feet; Patna 182 feet, and Darjiling 7,000 feet, above the sea-level. It can be inferred from these figures, that the soil near Calcutta is finer and better mixed than the soils of the other stations mentioned, while the soil of Darjiling is the coarsest and rockiest, the fertility of each portion depending on the kind of rock on which it rests.

104. The following table gives the latitude, longitude, elevation, mean temperature (M. T.) and rainfall (R.) of the principal towns of Bengal, Bihar and Orissa :—

	N. Latit.	E. Longit.	Altitude above mean sea-level.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average
Burdwan...	23°14′	87°54′	99 ft.	0·30	0·84	1·27	2·59	4·99	10·04	12·42	12·3	37·90	4·92	0·58	0·17	58·35″ R.
				66·1	70·5	79·6	85·1	84·8	84·6	83·6	82·8	83·1	80·6	73·3	66·4	(78·4) M. T.
Calcutta ...	22°33′	88°21′	21	0·44	0·97	1·31	2·37	5·48	11·77	12·96	13·94	9·92	5·42	0·60	0·32	65·50″ R.
				65·1	70·9	79·0	84·4	84·8	84·5	83·0	82·4	82·4	80·1	72·5	64·9	(77·9) M. T.
Cuttack ...	20°20′	85°54′	80	0·40	0·47	0·93	1·44	3·19	10·30	12·77	11·41	9·71	5·79	1·93	0·48	57·82′ R.
				71·5	76·1	82·8	87·5	88·7	86·2	83·3	83·2	83·1	81·4	75·1	69·8	(80·7) M. T.
Dacca ...	23°43	90°27′	35	0·29	0·97	2·45	5·84	9·25	13·25	12·93	12·38	10·19	5·40	0·68	0·23	73·86″ R.
				66·7	71·7	79·3	83·0	83·3	83·7	83·6	83·6	83·6	81·8	75·2	4·89	(78·7) M. T.
Darjiling...	27°3′	88°18′	7,421	0·74	1·11	2·35	3·72	7·10	25·25	29·86	26·19	17·66	6·50	0·21	0·16	120·85″ R.
				39·4	41·2	47·8	53·8	55·9	59·6	60·9	60·7	58·5	54·5	47·9	41·9	(51·8) M. T.
Durbhanga	26°10′	86°0′	166	0·47	0·57	0·28	0·61	2·23	8·20	11·90	11·32	8·92	2·70	0·08	0·11	47·39″ R.
				62.1	64·9	75·0	83·8	84·7	85·2	84·3	83·6	83·7	79·5	71·3	63·8	76·8)′′ M. T.
Patna ...	25°37′	85°14′	182	0·70	0·52	0·35	0·31	1·60	7·24	9·87	7·79	2·82	0·22	0·13	0·42	·29″ R.
				61·1	65·9	77·5	86·8	88·5	88·1	84·8	84·0	84·0	79·7	70·3	62·4	77·8) M. T.

105. The rainfall of some parts of Assam is higher even than that of Darjiling. The average annual rainfall of Cherapunji is as much as 475 inches. In some years it runs up to 600 inches. In Sylhet the averages for the several months can be seen from the following figures :—January—0·39″; February—1·59″; March—5·74″; April—13·73″; May—21 64″; June—32·02″; July—25·48″; August—25·69″; September—20·05″; October—8·31″; November—1·18″; December—0·30″; Annual average—156·12″. In Chittagong the annual average rainfall is 104″. It should be noted that even rice of the ordinary varieties grows better in the plains with a monthly rainfall of 5″ or 6″ at the germinating and ripening periods and 10″ or 11″ at the growing period. The rainfall of 20″ or 25″ per month is suitable only for hill tracts where the excess water can be easily drained away. Excess is often as injurious as deficiency for most varieties of rice. Some varieties of rice, however, can stand a rainfall of 20″ to 30″ per month. A monthly rainfall of 2 to 6 inches is the most favourable for ordinary vegetation, the lower figure being more suited for the early and late periods of the growth of Kharif crops, and also for the cold weather crops, as evaporation does not go on so rapidly in the cold weather as it does in the hot weather.

106. In selecting site for a farm the average monthly rainfall registered in the nearest meteorological station should be consulted. If the average rainfall in any locality in April May and June, and September, October and November is less than 1″ to 2″, or very precarious, and that in July and August over 12″ and in some years as much as 20″ or 30″ or more, such a locality should be avoided as naturally unfavourable for general farming unless it is a cool hill tract. Of course, the presence of canals or other special facilities for irrigation alters the question entirely.

107. The effect of rainfall slowly but surely in changing the physical character of the surface soil, where such soil lies

bare or is overgrown only by short grass, must not be ignored. The finer particles of clay getting washed out, the soil has a tendency to get lighter, which is an advantage only for soils which are too stiff. High winds, however, bring back some amount of fine dust and tend to keep up a balance. High winds which prevail on the sea-side districts are therefore not to be regarded as absolutely inimical to agricultural pursuits. In course of time they help to make sandy tracts loamy and fit for cultivation. On the whole, however, boisterous winds are not helpful to the proper growth of crops unless they are very short crops. An occasional gale may lay low and spoil a crop nearly ready for the sickle and where high winds are the rule, very few crops can be grown and the landscape is generally found quite bare of trees in such localities,—and how helpful trees are to agriculture in various ways, we will see later on.

108. What proportion of rain evaporates, what proportion sinks into the soil and feeds wells and springs, and what proportion finds its way by means of drains, streams and rivers, into the sea, depend upon the climate of the place, the season of the year, the porosity of the soil, the nature of the strata below, and the contour of the surface of the whole district or locality.

109. *Hail.*—The cause of hailstorms is not definitely known. They occur in Lower Bengal at the change of season from winter to summer, when southern breeze brings winds laden with moisture from the sea, and occasionally northern wind brings the clouds back towards the south from the Himalayas. These clouds are formed high up in the air (*i.e.*, Cirrus clouds) and not low down as in the case of Nimbus of the rainy season, and the colder regions of the atmosphere sometimes congeal the rain drops before they come down in the form of hail. Hailstones are larger or smaller in size as they come down from a greater or smaller height. The destruction caused by hailstones, though local, is often

very considerable. In Italy the damage to vineyards annually caused by hail is estimated at over £4,000,000. In 1880 an Italian savant, Professor Bombicci of Bologna, observed that showers of rain were most frequent in those places where gun practice shook the air and filled it with smoke. Then followed the well known American experiments (which have however led to no practical results) for artificially producing rain in a cloudless sky. In one direction Professor Bombicci's researches have led to a very practical result. In 1896 in Styria (Austria), a progressive vinegrower, Burgomister Stieger, started shooting with cannons against approaching storm clouds. He established shooting stations on the hills surrounding his vineyards at an altitude of from 300 to 800 yards. At every station he had from 5 to 6 mortars in a wooden hut, so that shooting could be proceeded with even during rain. His mortars are 18 inches long and they weigh about 160 lbs. each with a 3 centimetre chamber. He loads them with about 5 oz. of miners' powder. The clouds either disperse or come down in the form of rain and he has altogether avoided hail by this means. His example has been largely followed in Austria and Italy. There are now about 600 hail preventing stations in Italy.

110. *The weather chart.*—The agriculturist should be familiar with the reading of the weather-chart. The curved dotted lines that one sees on weather-charts,—called *isobars,* are imaginary lines, each connecting all those places which have at a given time the same barometric pressure. From a number of these isobars on a chart one can see at a glance the nature of the distribution of atmospheric pressure over a country at any given time. The Meteorological Department issues these charts every morning. The difference of pressure between one isobar and the next is called the gradient. A gradient of 4, means, that over a distance of 1 degree or 60 miles, the barometer has risen by $\frac{4}{100}$ or $\frac{1}{25}$ ths of an inch. When the isobars are drawn close to one another they indicate high or steep gradient; when they are wider

apart they indicate a low gradient. High gradient is followed by high winds and low gradient by light winds. Air does not blow directly from regions of high pressure to those of low pressure; the atmospheric movement caused by the rotations of the earth results in an alteration of the direction of the current. In the northern hemisphere if you stand with your back to the wind, the barometric pressure on the regions to your left hand is lower than on those to your right hand. In the southern hemisphere if you stand with your back to the wind the regions of lower pressure will be on your right hand. The same principle is expressed in other words thus : if you stand with the high barometer to your right and the low barometer to your left the wind will blow on your back. In the Southern hemisphere the reverse will be the case. Thus the *isobars* indicate direction of the wind, and the distances between the lines its strength.

111. Actual barometric readings have to be reduced to a common standard by the meteorological office, as the elevation of the place of observation and the temperature at the time of observation, make a difference in the height of the column of mercury, apart from the difference of pressure causing movements of wind. All the readings are therefore corrected or reduced to sea-level and 32° F, for comparison. A reduction has also to be made on account of difference of gravity due to difference of length in the diameter of the earth at different latitudes. All reduction is made for the latitude of 45°.

112. *Solar radiation* is also recorded in meteorological stations with the help of a radiation thermometer. This consists of a delicate thermometer having a dull blackened bulb and inclosed in a glass tube from which the air has been removed. This instrument is freely exposed to the heat of the sun and its maximum reading registered. The greatest amount of solar radiation which occurs during the day is indicated by the excess of this temperature over the maximum temperature of the air in the shade.

CHAPTER IX.

FERTILITY AND BARRENNESS.

FERTILITY and sterility are relative terms. One soil is more fertile than another and one more sterile than another. In nature there is no soil so absolutely barren that no method of draining, irrigation, manuring, or other treatment, has resulted in vegetation. Even *usar* lands of the N. W. P. and Oudh have been made to grow trees and grasses and superior crops, by a method of enclosing the land, of drainage and irrigation, and of manuring it with cowdung. Drainage and irrigation help the soil to get rid of its excess of effloresecent salts. Hard rock with no soil on it will, of course, grow no superior plants on it. But even soils which look like pure sand contain enough of plant food to yield crops of indigo, mustard, *til* and barley, if there is sufficient moisture in them.

114. *Fertility*.—(1) We have already seen that a fertile soil should contain all the essential ash constituents of plants in a *sufficient* and *available form*. But these cannot be readily ascertained. (2) A ten plot or five plot experiment is a practical guide for ascertaining their presence. (3) A still readier method of judging the fertility of soils is the ascertaining of the following facts: 1st, Do earthworms and grubs of insects abound to a sufficient depth in the soil? 2ndly, Do plants of various natural orders, including the leguminosæ, grow abundantly and luxuriantly on the soil? 3rdly, Are the bones of animals habitually living on the soil large-sized? 4thly, Do shells of snails &c., abound in the soil? A soil which is helpful to the growth of wild vegetation and which is able to support wild animal life in abundance and build the solid parts of their body which are rich in phosphoric acid and lime, must be rich soil. (4) The greater the absorbent co-eficient of a soil the greater is its fertility; and the larger the proportion of the decomposable silicates present in them, the more fer-

tile they are. We will speak of absorption and decomposable silicates more at length in the Part devoted to Agricultural Chemistry. By absorbent co-eficient is meant the number of cubic centimetres of Nitrogen absorbed in the form of Ammonia from a solution of NH_4Cl by 100 grammes of soil.

115. (5) Speaking generally, the greater the proportion of a soil which is dissolved by dilute acids the more fertile it is. The amount of soil substances soluble in water usually varies from ·2 to ·5%. But solubility in pure water is not a guide to the solubility of plant food actually undergoing in the soil. Some chemists, *e.g.* Hermann von Liebig, assumed that dilute acetic acid dissolved all those substances *available* to plants; but the acid secretions from rootlets are of a complex nature and no absolute guide as to the dilution to be used is possible. Professor Stutzer of Bonn was the first to use 1 per cent. solution of Citric acid for ascertaining the amount of *available* phosphoric acid in manures, and Dr. Dyer of London has carried out this method in dealing with soils, and arrived at very important practical results, in determining the proportions of available phosphoric acid and potash in soils. But the method gives no clue to the amount of available nitrogen in soils; and after all the question of fertility is mainly concerned with the amount of available Nitrogen present in the soil. Besides, acid secretions from all rootlets are not all equivalent to a one per cent. solution of Citric acid. Some secretions are more acid than others, and some plants therefore are better able to utilize the latent fertility of soils than others. The average acidity of root-secretions in terms of Citric acid, shown by hundreds of plants examined by Dr. Dyer, is not 1 but about 0·86 per cent. Coming to individual plants he found the variation was very great. Strawberry showed about 2% and a geum, (another plant of the order Rosaceæ) as much as 5·53%; while the examination of Solanaceæ and Liliaceæ gave very low results, about 0·36%. Cruciferæ and Leguminosæ averaged about

1%, while Gramineæ, Umbelliferæ, Compositæ, and Chenopodiaceæ showed only about ½%. These results, however, are very important in showing how some orders of plants, such as Rosaceæ, Cruciferæ and Leguminosæ thrive on poor soils while others such as Solaneæ, Liliaceæ, Gramineæ, Umbelliferæ, Compositæ and Chenopodiaceæ, need liberal manuring. Some plants of the same natural orders differed widely from others in this property of acidity of root-secretions and the figures should be judged according to this reservation.

116. (6) Fertility is governed by the *minimum* of a necessary ingredient. A soil may be rich in all essential ash constituents of plants but deficient or wanting only in one, and this deficiency or want may result in its barrenness. Soils derived from several rocks (*e.g.* alluvial soils) are better than soils from one rock, as there is no likelihood for such soils being deficient in any necessary constituent.

117. *Barrenness.*—(1) Soils containing an excess of Ferrous salts, *e.g.*, those formed by the oxidation of Iron pyrites (FeS_2). Land newly reclaimed from the sea contains Ferrous salts and are therefore temporarily barren. Tank earth freshly put on soils also makes them temporarily barren. $FeSO_4$ is soluble in water; but Ferrous salts combined with organic matter are soluble only in HCl. Soils which are too acid may therefore become barren when there are organic Ferrous salts present. Draining, liming and cultivation and exposure to the action of sun and air (which convert ferrous salts into ferric salts) are the means of reclaiming lands containing these poisons.

(2) Ammonium-Cyanate (NH_4 CNO) is poisonous to plants.

(3) Ammonium-Sulpho-Cyanate $\left(CS \begin{matrix} NH_2 \\ NH_2 \end{matrix} \right)$ is also poisonous to plants.

(4) More than 2% of soluble salts in a soil makes it barren; but a very much less proportion of common salt would make a soil barren. Lands reclaimed from the Sun-

derbans have to be drained of their excess salt before they become fit for cultivation. The *Usar* or barren lands of the N. W. P. usually contain an excess of sodium carbonate or sodium sulphate which are locally called *Reh*. These lands are being reclaimed by drainage, enclosure and light manuring. In 1895-1896 Dr. Voelcker determined by a series of carefully conducted experiments, the proportions of different sodium salts which might be present in a soil without preventing plant growth. To good garden soil, which was shown to contain no appreciable amount of any of the sodium salts, were added definite amounts of the three salts, sodium carbonate, sodium sulphate and sodium chloride. The amounts of salt varied from ·1 to 1%. Cereals and pulses were sown in separate pots. It was found that each of these salts retarded the germination. The cereals were affected by ·7% of carbonate or sulphate and by ·4% of chloride. The germination of the pulses was retarded by smaller amounts, *i.e.*, by ·2 to ·4% of Carbonate or chloride and ·7% of Sulphate. In the after-growth ·2 per cent. of the carbonate did harm whilst ·4 per cent. was quite fatal. Up to ·2% of sodium Chloride was formed harmless in a few cases whilst ·1% proved harmful in others. Sodium sulphate was less harmful, perfect growth both in the kharif and rabi seasons being maintained in the presence of ·5% of the salt. As in germination so in the after-growth, the leguminosæ were affected more than the cereals by the excess of soda salts. From this experiment it may be inferred how the lands reclaimed in Sundarbans though they become fit for growing rice very readily, are found unsuitable for pulse crops for a long time.

(5) Another cause of the barrenness of *Usar* lands is their impermeability to water.

(6) Waters from mines containing aluminium and magnesium salts often prove poisonous to plants, also waters containing copper, lead and other heavy metals, in solution.

CHAPTER X.

THEORIES UNDERLYING CULTIVATION OF SOILS.

THE objects of cultivation are :—(1) to allow roots to penetrate easily into the soil ; (2) to allow air and water to find easy access into roots and the soil ; (3) to allow absorption of moisture and of gases by soil to take place easily ; (4) to allow the microbes which help in the formation of nitrates to thrive more freely with free access of CO_2, O and N ; (5) to facilitate weathering of particles of soil chiefly by the action of O,CO_2 and H_2O. (6) Nests of parasites are also broken up and disturbed by cultivation. In one word, cultivation helps to bring about a mechanical, chemical and biological change in the character of soil.

119. The advantages of *protracted cultivation* are :—(*a*) better aerification, (*b*) better tilth and (*c*) exposure of insect and fungus pests to the action of birds, ants, sun-light &c. Cold weather preparation for *kharif* crops is actually practised by the best cultivators who know it improves the soil and gives them a better return. In the *rabi* season protracted cultivation is not always desirable as there is loss of moisture, the retention of which is needed for proper germination and growth.

120. The advantages of *deep cultivation* are :—(1) Roots can penetrate deeper and find food from the subsoil. Young plants have a great tendency towards root development. Hellriegel found that barley plants 10 days old and only in their third leaf had 42 lbs. of dry matter in their roots for every 58 lbs. of dry matter in the leaves and stem, while these relations were 29 : 71 when a month old, and 8 : 92 when ripe. He also found that barley plants with only one leaf having roots 9 or 10″ long, and when they had their second leaf, the roots were 20″ long, and barley plants a month old had

roots 3ft. long. A loose soil is of great help in developing roots of agricultural crops. (2) Roots penetrating deep, a crop can resist drought better as the soil is, as a rule, more and more moist the deeper one goes. (3) By deep ploughing the distances between plants can be shortened and as roots can then, instead of spreading out, sink deep in search of food. The *disadvantage* of deep cultivation lies in the fact of a great deal more of plant-food being made soluble and available than can be utilised by the crop, and the liability of this plant food so let free, being washed out. That most Indian soils have gone on yielding some return for years without manure, is to be accounted for by the fact of shallow cultivation being practised. Shallow cultivation is better than deep cultivation if no manuring is done. It results in a better conservation of food materials in the soil for future use, though the immediate return is poorer.

121. *Spacing.*—One object of tillage operations is to allow just sufficient space to each class of crops. A rice plant should have at its disposal one-third cubic foot of earth (about 20 lbs.). A bean plant should have at its disposal 1 cub. ft. of earth (about 60 lbs.); a potato plant 3 cub. ft. (about 190 lbs.) and a tobacco plant as much as 7 cub. ft. (470 lbs.). In an experiment conducted by Hellriegel with barley plants grown on jars, it was found out that a plant grown on a large jar containing 28 lbs. of earth weighed when ripe and perfectly dry 33,000 milligrams and bore 636 seeds; while 24 plants grown in a jar containing 11 lbs. of earth, weighed when dry 21,600 milligrams and bore only 384 seeds of a smaller size. The minimum space consistent with good yield should be allowed to each plant. For instance, though one potato plant will give the highest yield if it is given 3 cub. ft. of space it is more economical to have 2 plants in this space though these two will yield only a little more than the one plant. Potatoes planted in double rows 4 inches apart have been found at the Sibpur farm to yield more than those planted in single rows,

the distances in each case being 18″ × 9″, though the proportion of increase in the latter case is larger.

122. *Drilling and Hoeing.*—The space allowed between plants not only helps in root development and better growth, but also in weeding. Sowing in drills or regular lines and having a *perfectly level field*, one is able to do the weeding by bullock- hoes, when plants are of that height (3 inches to a foot) when bullock-hoes can be used without much loss by treading or breaking of stems. Where stem development is considered undesirable, as in the case of fibre crops, deep cultivation and thick sowing are advisable. The objects of ploughing and reploughing a field, of levelling it, of sowing seed in drills, and of weeding it with bullock-hoes, are evident from what has been said here and in the Chapter on Physical Properties of Soils. There is a further object in constantly using the hoe, besides weeding. Stirring the soil helps in removing the surface-pan that is formed after rain or irrigation. This prevents free access of air and the consequent weathering of soil particles. A sugarcane or potato crop should be hoed within a week after each irrigation to avoid caking of the soil. So great is the benefit derived from constant stirring of soil during the growth of crops that Jethro Tull a famous English farmer (1680—1740) jumped to the conclusion that tillage alone would serve instead of manure. Tull's principle was carried out to better issue by the Revd. Mr. Smith of Lois-Weedon, Northamptonshire. Operating upon a clay soil, Smith produced large wheat crops. His average for many years being 34 bushels in place of 16 bushels which was the average yield of the locality. He used no manure, but simply parcelled out his fields in strips 5ft. wide and grew the crop in drills on alternate strips in successive years. The vacant strips were spaded and ploughed deeply and frequently, so that by the disintegration of soil and absorption of CO_2 and combined N from the air, plant food enough for the next year's crop was secured. The

Lois-Weedon system clearly shows what tillage and spacing can do without a particle of manure for a good many years.

123. *Climatic influence.*—It should be mentioned here that deep cultivation is not so essential in warm climates as in cold climates. Disintegration of deep-seated soils is favoured by warmth, which generates CO_2 gas from organic matter and from disintegrating carbonates. Boussingault traced disintegration to a depth of 300 ft. in a warm mine. The corrosive action of air and water goes on much faster in warmer than in colder climates. The air in the pores of the cultivated soils is highly charged with CO_2; CO_2 is also found in natural waters usually to the extent of nearly 1 %, and more in water that has passed through soils containing limestones and vegetable matter. The CO_2 enables water to dissolve and convey to the plants many fertilizing substances which are hardly soluble in pure water. Phosphate of lime and phosphate of iron are not altogether insoluble in water charged with CO_2.

124. *Formation of nitrates.*—Every well-tilled field may again be regarded in the light of a saltpetre-bed. The value of nitrates for crops cannot be overestimated, and the formation of Potassium and Calcium nitrates is facilitated by open tilth in the presence of organic matter and a little moisture, by the action of nitrifying bacteria. The value of keeping land in tilth during the dry months (*i.e.*, from December to May) cannot therefore be over-stated. During the wet months ploughed up soils should be in crop, or else the excess of plant-food made available by tillage operations would be washed away by rain.

125. *Drainage and Irrigation.*—The object of draining the soil is to admit air, which water-logging would prevent. Where a field is so situated that draining is not feasible, the land should be ridged before sowing for the kharif season. Some crops are injured more than others by water-logging, but no crop except some varieties of winter and

Boro rice and aquatic plants, can stand water-logging throughout the season of its growth. Excess of moisture is specially injurious at and immediately after the period of germination, also at the periods of flowering and ripening. If it is necessary to irrigate for helping on germination, it is better to irrigate the field before sowing than after sowing.

126. *Bakharing and trenching.*—If a field is irrigated in preparation for sowing, it is advisable to wait until the soil is sufficiently dry for passing the *Bakhar* for the preparation of a tilth and for breaking the surface pan. Scattering of water on the fields after the sowing of seed, does, however, no harm. For this purpose the use of irrigation ladels or spoons is advised. Plates and broken pots are often used. But it is far more efficient to use the irrigation spoon (Fig. 1). *Trenching* brings the sub-soil



FIG. 1.—IRRIGATION SPOON.

to the top, and where the subsoil is known to be richer than the surface soil, this operation may be resorted to. It is, however, much more expensive than ploughing, as trenches have to be dug with spades. Trenching is done before valuable perennial plants such as roses, are planted. Trenching

is practised in Bengal for growing *mankachu* and in Ireland for growing potatoes. The Irish system of growing potatoes is called the Lazy-bed system. The land is divided into strips as in the Lois-Weedon system and from the bare strips earth is dug out and spread over the strips on which potatoes are planted. Two such operations are equivalent to the two earthings. These bare strips or trenches are used for planting potatoes the next year and earth is dug out of the strips which had potatoes on them the previous year. Trenching may be done with advantage in growing high class sugarcanes. Even ordinary sugarcanes should be grown in trenches, as from January to March when sugarcane should be planted, the soil is very dry at the surface. Shallow trenches may be dug with a double-mould-board plough (Fig. 2).

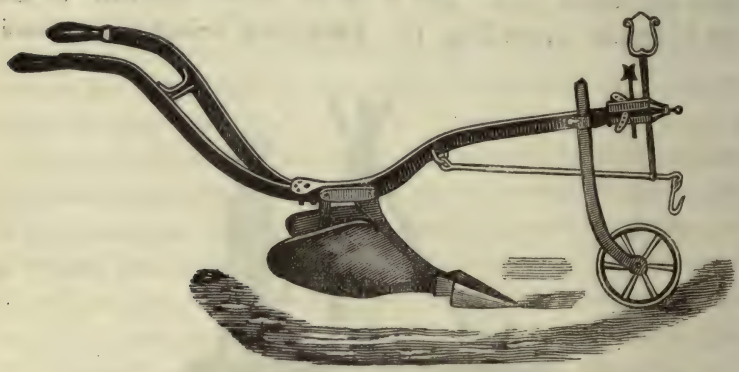


FIG. 2.—THE DOUBLE-MOULD-BOARD PLOUGH.

It costs less than one-sixth making trenches with a double-mould-board plough of what the cost comes to when trenching is done with spades. There are trenching ploughs used in Europe but these require very powerful horses to drive.

127. *Ridging.*—The object of *ridging* or *hilling* is to expose the largest surface to the action of air, heat, cold and moisture, and also to prevent accumulation of water immediately at the base of plants. For clay soils ridging is of great benefit especially when water logging is feared, so that most

crops which are cultivated from June to September should be grown on ridges or ridging done after the plants are a foot or two high. Sowing in trenches is advisable in the dry weather and so ridging should be done, specially in clay soils, for dry weather crops also. Ridging facilitates sowing in lines and using of hoes. The ridges can be split or spread out with the double-mould-board plough or a Hunter hoe

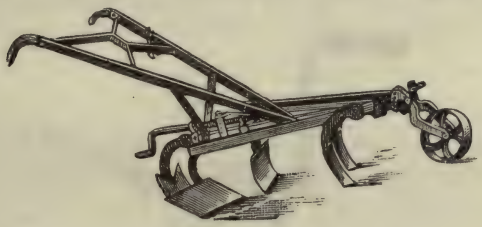


FIG. 3.—THE HUNTER HOE.

(Fig. 3) and the soil levelled, as in the case of sugarcane, potatoes, ground-nuts, mulberry and other crops which are benefited by subsequent earthing. The splitting of ridges after the plants are sufficiently high, acts like manuring. Sour and boggy soils are particularly benefited by ridging, as free access of Oxygen reduces the organic acids and converts sulphides into sulphates. Neither nitrites nor nitrates can exist in the black non-ærated stiff and damp clay until the soil is exposed to the action of air which is best done by ridging. The yellow Ferrous silicate of non-ærated soils also changes into red ferric silicate by ridging. Ridging or splitting of ridges thus serves the following purposes: (*a*) Covering, say potatoes, (*b*) preventing water-logging, (*c*) supporting maize, sugarcane and other tall crops and preventing their lodging, (*d*) manuring a growing crop with properly nitrified and ærated soil; (*e*) correcting acidity and poisons by ærification and (*f*) earthing.

128. *Subsoiling.*—The use of mould-boards for ploughing is of great importance as they invert the soil, thus

burying sods and exposing a new layer to the action of the elements. With the native plough scratching of the soil is effected but not over-turning of the soil. With the help of the mould-board the soil is overturned. *Subsoiling* and *subsoil-ploughing* are done with the object of admitting air and moisture into the subsoil. Subsoiling only stirs the subsoil, but subsoil-ploughing brings the subsoil to the surface. A subsoiler (Fig. 4) may be attached to a plough if four bullocks

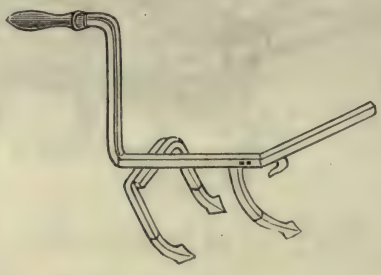


FIG. 4.—THE SUBSOILER.

are used. Surface soil is usually richer, especially in organic matters, than the subsoil, and it is undesirable, as a rule, to bring up the subsoil to the surface by trenching or subsoil-ploughing. But it is very desirable to stir the subsoil for certain crops with the object not only of admitting air and moisture into it and facilitating the penetration of roots, but also of breaking the impervious pan which is formed by the sole of the plough. Subsoiling may be also done by a country-plough being passed behind a plough fitted with mould-board, the plough on the rear stirring the soil of the furrow made by the front plough in the same way as a subsoiler working behind a plough does the work. Deep ploughing is also best done in this country by passing one plough behind another along the same groove.

129. Another object of deep-ploughing, trenching or subsoiling is to increase the water-holding-capacity of soils. Loose earth receives and stores more water than compact

earth. Ploughing a field in May after a very heavy shower of rain one may find the furrow turned up wet only superficially, and dry at its deeper layers. Loose earth could retain over 40 per cent. of its weight of water while the same earth in a very compact condition would hold only about 25 per cent.

130. *Rolling and Mulching.*—On the other hand, soil which is too loose gets dry too quick and does not firmly support the plants growing on it. A tilth too open is not desirable especially for light soils, which should be rolled after ploughing and harrowing. *Rolling* and *mulching* are practised for keeping in moisture. By 'mulch' is meant anything laid on tilled soil to keep in moisture, such as leaves and straw, bits of cowdung cake, &c.. Too free a subsoil may also result in water sinking too quick leaving the surface soil hungry. Extremes should therefore be avoided in tilling operations.

131. *Harrowing.*—The object of harrowing is to level the land after ploughing and to collect the weeds. Where the land has to be ridged the operation of ridging follows that of harrowing. The native ladder acts both as a harrow and a roller inasmuch as it collects weeds, levels the land and gives it a certain amount of compactness. But the work is done very imperfectly by a ladder. The beam or the levelling board used in other parts of India is not effective in collecting weeds, but it is more effective than the ladder for levelling land and giving it a compactness. It is advisable to introduce a light harrow and a light wooden roller (which can be easily managed by a pair of bullocks), in the farm operations of this country.

132. *Burning the sod* is recommended only for new jungle land, for peaty soils and for some clay lands, *i.e.* on clay lands which contain a good deal of silicate of potash and some lime. The lime decomposes the silicate and liberates some of the potash. All clays are benefited by moderate burning which makes the land more friable and less plastic. Moderate burning *i.e.* burning in slow heat, being essential,

stifle-burning should be resorted to, except in new jungle land where the loss of nitrogenous matter would not be so severely felt as in ordinary agricultural land. Stifle-burning corrects acidity of soils, and clears it of weeds, insects, fungi and their seeds. If burning is done too freely not only is there too much loss of organic matter and nitrates, but the physical character of the soil becomes deteriorated, *i.e.* impervious brick-like masses are formed on the surface.

133. *Warping.*—As it is not practicable to improve soil by mixing with it soil of a different character carted from another locality, the same result is sometimes achieved in sandy, stony or peaty soils, favourably situated, by the operation known as warping. A bund 2 or 3ft. in height is put up around the land to be improved, and the enclosed land is sometimes further partitioned off by smaller bunds. Then the muddy water of a stream, at the beginning of the rainy season, is diverted into this area, where it flows from one compartment to another, until the whole area is filled. A film of silt is deposited and by repeating the operation several inches of silt may be accumulated on the land in one season. Where tides come in warping is very easy to regulate by means of a sluice or flap-gate, as in the low lands to the south of the College, where the object is not so much the fertilizing of the land as the raising of its level.

PART II.

IMPLEMENTS.

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CHAPTER XI.

MOTIVE POWERS OR PRIME MOVERS.

WORK done on the farm may be divided into seven classes in those countries where agriculure has attained a very high state of efficiency. These are: (1) Work of man; (2) Work done by animal-power, *viz.*, horses, mules, donkeys, bullocks, &c.; (3) Work done by wind-power; (4) Work done by water-power; (5) Work done by steam-power; (6) Work done by explosive action of gas and oil engines; (7) Work done by electricity.

135. *Work of man.*—Where work has to be done on a large scale the first form of work is the most expensive, the second less expensive, the third still less, and so on. Wherever therefore animal-power, wind-power, water-power, steam-power, &c. can be made use of, the employment of hand-power should be avoided, as a general rule. In this country the management of labour is of very great difficulty. An Indian labourer who will handweed $\frac{1}{10}$th of an acre a day working for himself, can hardly be got to do $\frac{1}{40}$th of an acre for his employer. Habitual dishonesty in work is the exception rather than the rule in European countries. Apart from this, there is the general advantage of mechanical over hand-power. In hilling an acre of maize or potatoes, for instance, with *kodalies* the cost comes to Rs. 5 or Rs. 6 near Calcutta, while with a ridging plough or a Hunter hoe the same work can be accomplished at an expenditure of only about 8 to 12 annas. Of course, work of such a nature as requires

reason and judgment for guidance must be done by man; *e.g.* attendance on cattle and other live-stock; planting and transplanting, management of machinery, &c. Some work which can be done by machinery is more cheaply and conveniently done by hand power; *e.g.* binding of sheaf. In managing Indian labour it is very necessary to have a *sirdar*, or foreman, or overseer to look after the labourers, unless the proprietor of the farm can do so himself. If the proprietor is himself an expert cultivator accustomed to doing rough work he can always get more work out of labourers by himself working with the gang. Working Indian labourers on the gang system is very important, and yet each man should be given a separate piece of work to do that the amount and quality of each man's work may be judged. It is not of course necessary to employ all the labourers on the same field and in the same work at the same time. It is enough if the overseer can easily see each man from where he is, doing his allotted piece of work. When labourers distribute themselves in different parts of a farm and work outside the immediate ken of the foreman, they do very little work. There are some works, such as broadcasting, dibbling or hand-drilling of seed, planting cuttings, &c., which need close watching. There are usually two ways of doing a work,—a careful and a careless way. It is less troublesome doing work carelessly and unless labourers are immediately corrected when they take to careless ways, they get into the habit of working carelessly. A great deal depends upon proper habits being engrafted to labourers. When Indian labourers once get into the habit of doing some work in the proper manner, they continue to do the work in the proper manner even when they are not very closely watched. Some of the cultivators' habits are hereditary, and some castes are therefore found doing work faster and in a neater manner than others. It is less troublesome, for instance, sticking sugarcane cuttings in prepared soil, any how, so that some

are planted 6 inches deep while others only 1 or 2 inches deep. But whenever a labourer plants a cutting 1 or 2 inches deep, he must be made to plant it 5 or 6 inches deep, until a proper habit is established. A labourer, however, who is accustomed to do sugarcane planting in his own family, will habitually plant the cuttings 5 or 6 inches deep when planting them erect, or 3 inches deep when planting them horizontally. If expert labourers can be secured it is always better. But cultivators in this country go in for cultivating so few crops that expert labourers can be had only for doing the cultivation of two or three crops properly. An ordinary cultivating labourer will transplant paddy neatly and fast, broadcast jute and *kalai* seeds evenly, harvest the paddy and the jute in the proper style, but in doing the cultivation of a new kind of crop he will be found awkward and slow.

136. The calculation for hand-power is fraught with more difficulty than that for steam-power, horse-power, or bullock-power. An English farm labourer in his own country does far more work than an Indian farm-labourer, and an Indian farm-labourer will do far more work for himself than for another party, while one class of labourers even in the same part of the country do habitually more work than another class of labourers. Further complication arises from the fact that a certain class of labourers will do a certain kind of work well while they will do another kind of work very imperfectly. The Sonthal labourer will dig more than a Bengali labourer, but the latter will transplant more paddy. The Sonthal woman will transplant a great deal more paddy than the Sonthal man. An English farm-labourer in digging does 250 ft.-lbs. of work per minute. In the Bengal Famine operations of 1897 an average quantity of about 100 cubic ft. of earth was raised 3 ft. during 6 hours and the weight of a cubic ft. of earth being taken as 100 lbs. the work done in 6 hours was about $100 \times 100 \times 3$ ft.-lbs. or, $\frac{100 \times 100 \times 3}{6 \times 60}$ = about

83 ft.-lbs. per minute. As the famine labourers were mostly non-professional diggers and as they were somewhat weak, the work done by the average Bengali labourer habitually employed in digging may be calculated at about 125 ft.-lbs. per minute though cases of 200 to 300 cubic ft. of earth being dug by one man sometimes came to notice even in the famine operation. Basing on this calculation of a Bengali labourer being able generally to perform only half the amount of work of an English labourer, he should be able to show :—

(1) 125 ft.-lbs. of work per minute in digging.
(2) 165 ft.-lbs. „ „ „ „ filling dung in carts.
(3) 250 ft.-lbs. „ „ „ „ pitching corn.
(4) 2,000 ft.-lbs. „ „ „ „ rowing a boat.

137. In filling dung in carts, an English labourer will load 30 to 40 cubic yards in 10 hours to an average height of 4 ft. The weight of fresh dung is 12 to 14 cwts. and of well-made rotted dung, 1 ton, per cubic yard. 50,000 lbs. lifted into carts 4 ft. high means 200,000 lbs. raised 1 ft. high per day of 10 hours, which is equivalent to 330 ft.-lbs. per minute. In pitching corn an English labourer can pitch the corn of 1 acre per hour, *i.e.* 2 tons of grain and straw. The average height to which the corn is pitched is 6 ft. 5000 lbs. lifted 6 ft. high=30,000 ft.-lbs. per hour *i.e.*, 500 ft.-lbs. per minute.

138. The relation between horse-power and human-power is as 7 : 1 in the case of the English labourer. We may approximately put down the relation between horse-power and the power exerted by a Bengali labourer as 14 : 1. But it entirely depends upon the character of the particular work whether human power is so much less efficient or still less so. For steady draught purposes a pair of Bengal bullocks is at least ten times as efficient as a labourer, though theoretically a Bengal bullock, as we shall presently see, is only 1½ times as powerful as a Bengali labourer.

139. Calculating wages at 3 annas a day, the average

cost of the principal farm operations where hand-power is partly or wholly employed, is given below : –

	PER ACRE. Rs.	A.	P.
First ploughing with laddering (inclusive of the cost of keep of cattle)	1	2	0
(exclusive of cattle) ...	0	12	0
Second and Subsequent ploughing with laddering ...	0	12	0
Ditto (exclusive of cattle) ...	0	9	0
Grubbing, harrowing, rolling, bakharing (inclusive of cattle)	0	6	0
Making furrows with ridging plough	0	12	0
Making furrows with *kodalis* (country spades) $3\frac{1}{2}$ ft. apart and 1 ft. deep	3	12	0
Planting sugarcane or mulberry cuttings or seed-potatoes, including covering with earth ...	4	8	0
Irrigating with *sewny*, or Barrakar pump ...	3	0	0
Irrigating with *dôn*	1	8	0
Spreading manure in trenches, including covering the manure	1	8	0
Spreading manure broadcast	0	6	0
Hilling with *kodalies*	5	0	0
Hilling with Hunter hoe (inclusive of cattle) ...	0	8	0
Spading fallow land for thorough digging ...	6	0	0
Hand hoeing*	3	0	0
Wheel hoeing with Planet Jr. hoe	0	9	0
Cutting and stripping sugarcane	11	4	0
Cutting paddy with hooks or sickles	1	8	0
Thrashing and winnowing paddy with hand thrashing and winnowing machines	4	8	0
Transplanting paddy	1	2	0
Sowing seed broadcast	0	6	0
Sowing seed in drills wlth Planet Jr. hoe ...	1	8	0

* Cultivators usually spend Rs. 6 per acre for hand hoeing paddy, as they have to pay 6 to 8 annas a day to a labourer at the hoeing season.

140. *Piece-work.*—Wherever possible work should be got done by contract at the above rates, even by labourers employed by the month. Piece-work or work done by contract is however apt to be done carelessly unless proper supervision is exercised.

141. *Animal power.*—Horse, cattle, or donkey-power is utilised for three classes of work. (1) For direct draught or haulage, as in drawing carts, ploughing &c. (2) For application to machines to turn a capstan giving motion to a wheel or windlass, *e. g.* in thrashing corn, ginning cotton, pumping water &c., by animal power. (3) For pedalling to turn a tread-mill for communicating power or lifting water. Work done by draught-animals, aided by human reason, is less expensive per unit than work done by hand-power, and it is by the substitution of hand-power by cattle-power that a great many agricultural improvements may be effected in this country. With a Hunter hoe (it may be repeated here) which is easily drawn by a pair of country bullocks, maize or potato fields may be ridged at a cost of about 8 annas per acre, while the same work done by hand-power with *kodalies* will cost Rs. 5, and if the labourers are not closely watched the cost will even exceed this amount. Hand-weeding is more efficient, but for most crops hoeing with bullock-hoes will be found sufficiently effective. When mechanical power (*i.e.* steam &c.) cannot be conveniently and extensively employed *e.g.*, when fields are small, uneven and crooked, or cut by natural water-courses, it is better and cheaper to cultivate with the aid of draught animals than with steam. As Indian fields are not like English fields, which are each 10 to 20 acres in area, and as they are enclosed by *ahirs* or borders and cut by natural water-courses, steam ploughing &c. are quite unsuitable for Indian conditions. The introduction of implements suitable for the employment of bullock-power more extensively than it is now, is of the utmost importance. Native cultivators are, as a rule, averse to using mechanical

appliances. In this as in other matters, they have got to be *habituated* to see the advantage of using machanical appliances before they begin to take to them. Even when the advantage of some mechanical appliance or some new method has been demonstrated to them, they are apt to fall back on their own old appliances and the methods to which they had been accustomed. In dealing with Indian raiyats the questions of habit and of local influence are of considerable importance.

142. *Bullock-power.*—Bengal bullock-power may be ascertained in the following way :—A pair of Bengal bullocks, it may be observed, walk about 66 ft. per minute while ploughing, the draught exerted being about 100 lbs. The fields of the Sibpur Farm being all 66 ft. wide the facts stated here have been constantly tested. The work done per minute by a pair of Bengal bullocks is therefore $66 \times 100 = 6600$ ft.-lbs. per minute. *i.e.* 3300 ft.-lbs. per bullock per minute. The work done by one English farm-horse can be similarly ascertained to be about 33,000 ft.-lbs. (which is the theoretical H.P., the unit of measurement for steam and other high powers). The Bengal bullock therefore performs ten times less work than the English farm horse. The actual horse or bullock-power is only $\frac{2}{3}$rds of the nominal horse or bullock-power, as in the above calculation no account is taken of loss of time in turning, for stoppages while the ploughman is smoking &c. So compared to Watt's Horse-power or theoretical H.P. the actual English horse-power and Bengal bullock-power are respectively as 33,000 : 22,000 : 2,200 ft.-lbs.

143. Draught animals do not perform the same amount of work while working a chain pump or thrashing machine by walking round and round a track, as they do while ploughing. 1st the position of the animals in a bullock-gear is inconvenient; 2ndly, they cannot exert their full power in a bullock-gear; and 3rdly force is lost by pulling at an angle.

144. In England a pair of horses is calculated as suffici-

ent for keeping 50 acres in cultivation ; and our cultivators calculate 1 yoke of oxen as being sufficient for keeping 16 bighas (about 5 acres) in cultivation. Thus from actual practice also it is deducible that an English farm-horse is able to do ten times as much work as a Bengal bullock, and that the work done by a Bengal bullock, while ploughing, is 2,200 ft. lbs., as stated above. On light soil 3 horses are kept in England for every 100 acres of land. On this calculation we would require in Bengal 30 bullocks for working 100 acres of light land or about 1 yoke of oxen for 20 bighas. In stocking a farm in Lower Bengal these figures should be borne in mind.

145. It will be long before bullock-power will be replaced by steam or electricity in this country, for farm operations. Steam and other engines deteriorate as time goes on ; cattle have a tendency to multiply. That horses are a farm-produce is one of the chief considerations why horses are mainly employed in English farm operations even where steam is applicable. Judiciously managed, the employment of bullock-power in a farm not only costs little; but it actually becomes a source of income to the farm. From the 3rd year of their life to the 10th year bullocks can be worked and afterwards they can be fattened and sold off, while a few cows may be maintained on the farm to keep up a supply of vigorous young stock. Such works as churning, thrashing, husking pulping, pumping, which are more cheaply done by wind or steam-power, can be done by bullock-power when the bullocks have a slow time and when there is not much work to be done on the farm.

146. To help the more efficient employment of bullock-power it is necessary to have a bullock-gin or bullock-gear to which such light machinery such as thrasher, huller, winnower, churn, pump, pulper, chaff-cutter or cake-crusher, can be attached. The attachment is made by means of a leather belt which communicates the motion of the revolving capstan (to which

the bullock-shaft is attached by means of a large cog-wheel which turns a smaller pinion-wheel) to the machinery concerned. There are many forms of gearing for obtaining increased speed, even for working such high-speed machines as centrifugal cream separators. The best and most efficient is Messrs. Lister's Triplex Horse-gear (Fig. 5) which requires no intermediate gearing. The lay-shaft makes 64 revolutions to one of the horse, so that by attaching a 24-inch cog-wheel at the end of the shaft working in gear with a small pinion it is possible to drive a cream-separator without the intervention of a leather belt or rope.

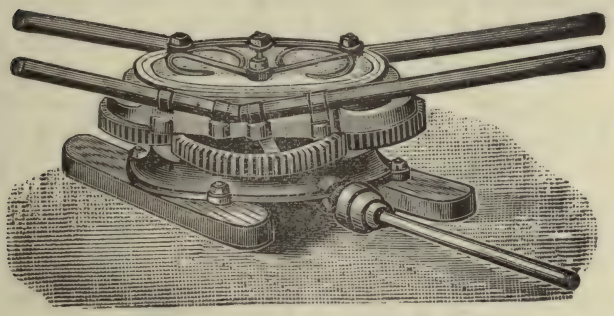


FIG. 5.—MESSRS. LISTER'S TRIPLEX HORSE-GEAR.

147. *Wind-power.*—Though wind-mills are going out of fashion in highly civilized countries, they seem to be specially appropriate for India. The improved wind-mills or aeromotors, the introduction of which is being attempted by the various Agricultural Departments of India, cost so much at the first setting up, that they do not seem to be adapted for the use of the ordinary *raiyat*. The old-fashioned English wind-mills which have been introduced into British colonies of

South Africa with such success, seem well adapted for India. Wind-mills of cheap construction are popular in the United States also, whence we get the Chicago aeromotors. A cheap wind-mill is constructed without a vane, and the wheel is so fixed as to be driven only by the prevailing winds during the dry season, which in Lower Bengal are from north and south, or a few points off either way. The sails would catch the wind only when it is about northerly or southerly, and the mill would thus be set in motion. When the wind is easterly or westerly it would not move. It is necessary to enclose the lower part with boards or walls so as to exclude the wind from all sides except from the top, and the action

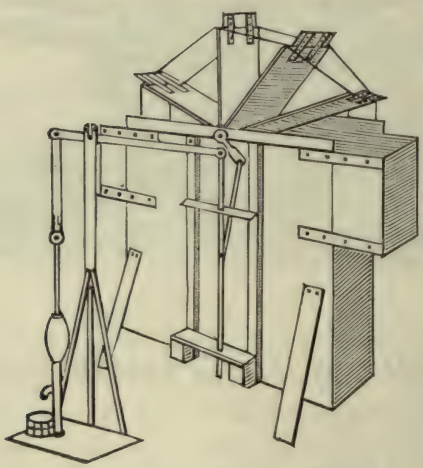


FIG. 6.— THE HOME-MADE WIND-MILL.

of the mill should correspond to that of an over-short water-wheel. The figure given here (Fig. 6) illustrates a wind-

wheel which would cost only about Rs. 50 constructing. There is an iron axle to which are 6 fans or sails (5ft. × 6ft.) attached. The "Jumbo-box" is 12 ft. long by 8 ft. wide by 6ft. high. The axle is mounted on posts. Such a wind-mill has been known to pump water for 100 head of cattle from an 18 ft. well. The whole arrangement, if a pump is provided, can be set up by a village carpenter and a blacksmith. Any old lumber, such as split rails, old packing boxes, tin from old tin roofs, can be pressed into the service in the construction of these mills. The sails may be constructed either narrow and tall or square or oblong, the object being the offering of a large surface of obstruction for the wind. With proper mechanical arrangements these home-made mills can not only be used for pumping water, but also for working a grindstone, for sawing wood, for churning butter, for cutting chaff, for crushing oil-cake and doing other ordinary barn-door work. The old forms of wind-mill (called post-, tower-,or smock-mill) with a 15½ ft. radius and with a breeze of 13ft. per second, yield about one horse-power of energy.

148. *Power-Mill.*—In a large farm, where it is worth while having chaff-cutters, cake-crushers, &c. worked by wind or water-power, it is important to have the mill working at all seasons, specially at the wet season, when indoor work is preferable to outdoor work. The self-adjusting wind-mills of modern construction are preferable for constant work, as even with very light wind they do fairly good work, and the vane turns the wheel in such a manner that whatever the direction of the wind may be, the sails catch it and work the mill. The whole expense is incurred in the first erection. Afterwards oiling once a week is all that is needed. Rs. 2,000 laid out in the erection of a power-mill, one form of which is represented here (Fig. 7), can be got back in two years, in a properly organised farm.

149. Wind-mills of modern construction, called also aero-motors, are either vertical or horizontal. The mill represented

here in fig. 7 is a vertical mill, the motion of the wheel being vertical. The sails of a horizontal mill move horizontally.

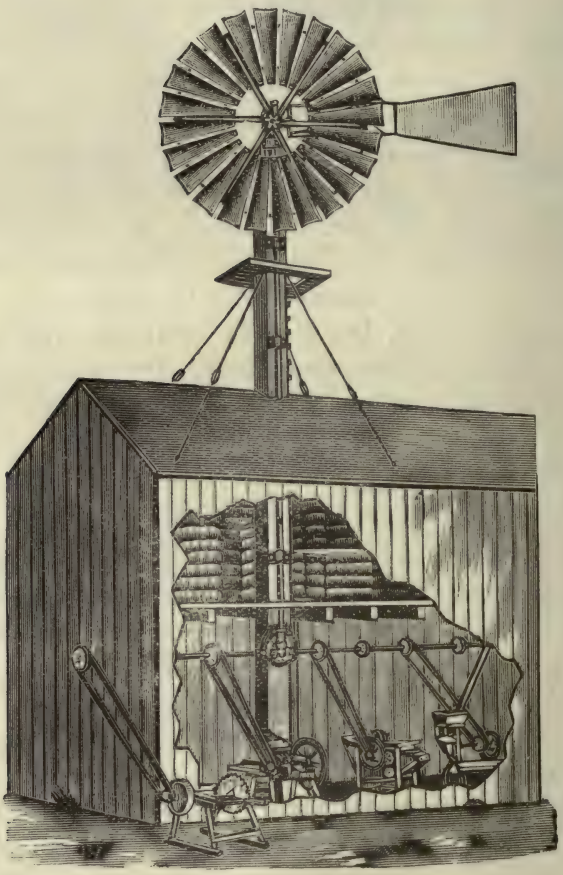


FIG. 7.—THE AEROMOTOR (POWER-MILL).

150. *Useful tables.*—A few tables regarding velocity of wind &c., may be found very useful in connection with the question of efficiency of wind-mills.

Velocity of wind.

Popular Description	Equivalent in miles per hour.	Equivalent in feet per second.	Force exerted per square foot of sail.
Breeze hardly perceptible ...	1 „ „	1·47 „ „	·005 lb.
Gentle breeze ...	5 „ „	7·33 „ „	·123 „
Pleasant breeze ...	10 „ „	14·67 „ „	·492 „
	15 „ „	22·00 „ „	1·107 „
Brisk gale ...	20 „ „	29·3 „ „	1·968 „
Very high wind ...	40 „ „	58·6 „ „	7·872 „
Storm ...	50 „ „	73·3 „ „	12·300 „
Hurricane ...	100 „ „	146·6 „ „	49·200 „

N.B.—By 'average wind' is to be understood wind blowing at the rate of 15 to 16 miles an hour.

Discharge of water by pump.

Diameter of pump-cylinder.	Weight of water contained in 1ft. length of cylinder.	Amount of water discharged by every inch of pump-stroke.
1½ inch	·774 lbs.	·0076 gallons
2 „	1·372 „	·0136 „
2½ „	2·159 „	·0212 „
3 „	3·087 „	·0306 „
3½ „	4·214 „	·0416 „
4 „	5·488 „	·0544 „
5 „	8·575 „	·0850 „

Efficiency of aeromotors.

Height to which water is to be lifted.	Diameter of pump-cylinder when 8-foot mill used.	Gallons per hour when 8-foot mill used.	Diameter of pump-cylinder when 12-foot mill used	Gallons per hour when 12-foot mill used.
5 ft.	8 inches	3,634	10 inches	5,508
10 ,,	6 ,,	1,763	8* ,,	4,700
15 ,,	5 ,,	1,224	8 ,,	3,525
20 ,,	4½ ,,	998	6* ,,	2,644
25 ,,	4 ,,	784	6 ,,	1,983
30 ,,	3¾ ,,	689	5 ,,	1,377
40 ,,	3½ ,,	600	5 ,,	1,377
50 ,,	3¼ ,,	518	4½ ,,	1,115
60 ,,	3 ,,	440	4 ,,	882
70 ,,	2¾ ,,	371	4 ,,	882
80 ,,	2½ ,,	306	3¾ ,,	776
100 ,,	2¼ ,,	248	3¼ ,,	586

151. *Calibre of pump-cylinder.*—The above table gives the efficiency of aeromotors when the velocity of wind is of the average strength, *i.e.*, about 16 miles an hour. A mill with a wheel 8 feet in diameter is constructed to have a pump-stroke of 6 inches. A mill with a 12-foot wheel is constructed either with 9-inch or 1 foot pump-stroke. The two pump-cylinders with 8-inch and 6-inch diameters noted with asterisks* in the above table are assumed to have the long stroke (1 foot) attachment. With average velocity of wind an 8-foot mill undergoes about 40 strokes and a 12-foot mill about 30 strokes per minute. With lighter winds the efficiency is less and with stronger winds, more, than what is indicated in the table. For irrigation purposes it is best to employ a cylinder of the calibre indicated in the table so as to get the maximum benefit from the aeromotor. But cylinders of smaller calibre than those

indicated in the table may be used specially for small depths. The table gives the maximum diameter of the cylinder which can be safely employed for a given depth. Where an 8-inch cylinder may be employed it is false economy (specially when land has to be irrigated) to use a 2 or 3-inch pipe; though it should be noted that a very light breeze (*i.e.* of the velocity of 2 or 3 miles an hour) will work a 2 or 3-inch pump when an 8-inch pump will require a 15 or 16-mile breeze to work it. Local conditions, as to velocity of wind at the seasons in which irrigation is needed, and the depth of water at these seasons, should determine the choice of the calibre of the pump-cylinder. The pump should always be provided with a handle, as when the breeze is light, a little coaxing with the pump-handle, results in the wheel turning and continuing to turn with a comparatively gentle breeze making further working of the handle unnecessary.

152. *Efficiency.*—A 12-foot mill develops 2½ horse-power with average wind (*i.e.* wind blowing about 16 miles per hour).

153. *Erection.*—The tower should be erected about 15 ft. higher than surrounding trees and buildings. After the tower has been erected the four anchor-posts which form the base of the tower should be protected with masonry work, that the tower which should be set plumb may always remain so. Even rat-holes tunnelled underneath the anchor-posts on one side will make the tower lean on that side.

154. Steel wind-mills constructed by Messrs. S. Freeman & Sons, B. 21 Produce Exchange, New York City, U. S. A., are priced thus:—

8 ft. wheel (galvanized	...	42½ dollars	(× Rs. 3)
12 ft. „ („)	...	100 „	„
Galvanized steel tower for 8 ft. mill, 40 ft. high	...	58½ „	
Ditto 80 ft. high	...	150 „	
Ditto for 12 ft. mill 40 ft. high	...	87½ „	
Ditto 80 ft. high	...	210 „	

Attachments for power-mills for feed-grinder &c., are also supplied by the aeromotor companies. The actual cost of erecting the aeromotor at the Sibpur Experimental farm (which has an 8 ft. wheel and 40 ft. tower) was about Rs. 900.

155. Aeromotors with sails moving in the horizontal plane have been also invented. Rollason's horizontal wind-motor has been actually utilized in working a complete plant of fifty 16 candle-power incandascent lamps, from which it is easy to judge of its capacity for motive power. Messrs. Rollason calculate that with a wind of 16 miles per hour, an 8-ft. motor wheel (horizontal) generates $\frac{1}{4}$ horse-power; a 10-ft. wheel 1 horse-power, a 15-ft. wheel $2\frac{1}{4}$, and a 20-ft. wheel 5 horse-power. A Freeman's 16-ft. vertical wheel (which is a power-mill) generates 5 horse-power under the same conditions as a 20-ft. horizontal wheel of Messrs. Rollason's. With stronger winds up to 8 horse-power is developed. So this represents the maximum capacity of wind-mills, under ordinary conditions. When a storm is blowing the mill should not be geared at all for work,—the vane being disattached from the wheel by pushing the brake up. The vane and the wheel will then both be in the same direction as the wind and little resistance will be offered by either.

156. *Water-power.*—In utilising water-power initial expenditure is the only item worth considering. There is no loss of time in utilising wind and water-power as there is in using steam-power, and there is no expenditure on account of coal and cartage of water. If there is a constant flow of water, it is a more reliable and efficient motor than wind. A high elevation or a precipitate fall is not necessary if the current is sufficiently strong. The current, that is, the speed of water, may be measured by a simple means. Measure a distance of, say, 20 yards, along the centre of the stream or channel intended to be utilised, and let a bit of cork or any kind

of light float be allowed to pass along this distance of 20 yards. This gives the velocity of the water at the middle of the channel. At the sides and at the bottom, the velocity is less. If the bottom and the sides of the channel are made of bricks, 17 per cent. of the velocity ascertained in the above manner, should be taken off; if the sides and bottom are of earth 29 per cent. should be taken off, and if they are stony, irregular and rough, 36 per cent. should be taken off, in estimating the average velocity of a stream. Then by multiplying the section of the stream utilised by the reduced velocity one gets the quantity of water expressed in the terms of so many cubic feet per minute.

157. *Efficiency.*—The effective horse-power of the principal forms of water-motors are :—

	Of the theoretical horse-power.
For ordinary Undershot wheels	35 per cent.
For ordinary Breast-wheels	55 „
For ordinary Overshot wheels	68 „
For Turbines	70 „
For new fashioned wheels and turbines ...	75 to 80 per cent.

The effective power varies according to the ingenuity of construction and erection, which minimises friction. Properly constructed a breast and overshot wheel and a turbine may have a 75 per cent. efficiency. On the 75 per cent. basis, it has been ascertained that the height of the fall in feet multiplied by the number of cubic feet of water per minute, and divided by 706, gives the actual horse power. So,

$$\frac{\text{horse power} \times 706}{\text{Height of the fall in feet}} = \text{No. of cubic ft. of water required per minute ; and } \frac{\text{horse-power} \times 706}{\text{quantity of water in cubic feet per minute}} =$$

height of fall in feet required to produce the horse power. The undershot wheel though less efficient is more suitable for level countries like Lower Bengal. If the floats are

made curved with their concavity backwards, increased efficiency will be obtained to that which is obtained from flat vanes. The race or channel should be short in the case of all the wheels, though the tank or reservoir of water should be as large as possible, that the current may be even and uninterrupted. If the stream is constant a reservoir is not required but a burnt clay-pipe on a masonry channel or race, increases the efficiency of a wheel. When a water-wheel is drowned *i.e.*, when the tail is not sufficiently low to allow the water to run off freely, its efficiency is reduced by about one-fourth. The breast-wheel should have buckets instead of floats, that by means of the weight of the water in the buckets the wheel may go down more readily, the buckets discharging their contents while going down. Thus constructed the breast-wheel may be of the same efficiency as the overshot wheel which receives the impulse earlier. But the bucket arrangement still further improves the efficiency of the overshot wheel. Fig. 8 represents in section an overshot wheel with the bucket arrangement. Fig. 9 repre-

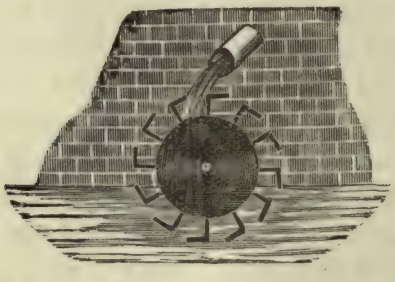


FIG. 8.—THE OVERSHOT WATER-WHEEL.

sents a breast-wheel with the ordinary kind of float, while Fig. 10 represents an undershot wheel with curved floats. The lower portion of the wheels should be encased in brickwork

in each case, the axle of the wheel resting on this brickwork whence the power is transmitted to the various machinery worked in the barn. The diameter of the overshot wheel

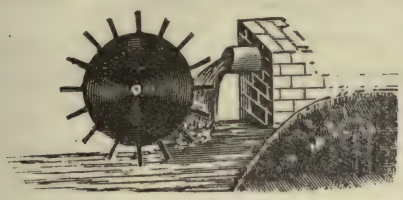


FIG. 9.—THE BREAST-WHEEL.

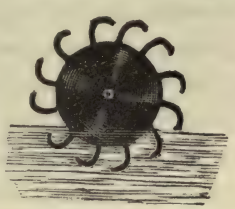


FIG. 10.—THE UNDERSHOT WHEEL.

should be a little less and that of the breast wheel somewhat greater than the height of the fall of the water.

158. The *Turbine* (Fig. 11.) is a more complicated machine than the ordinary water-wheels and not being capable of repair in villages it is not so suited for agricultural requirements,

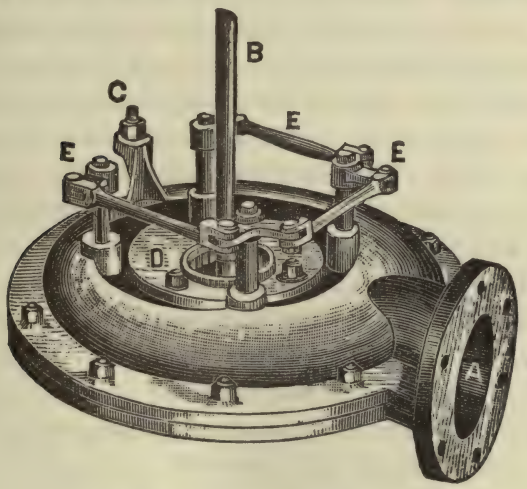


FIG. 11.—THE TURBINE.

though it will prove far more useful where it can be introduced. It is not necessary to have a very great fall of water to work a turbine and the wheel occupies very little space. As it can be

run with high speed it is better adapted for driving machinery of different kinds. The water is received at the supply pipe (A), whence it is directed by curved guide-blades to the vanes of the wheel which revolves on a pivot. There is a screw arrangement at (C) for raising this pivot. The wheel is rigidly fixed at the bottom of a shaft (B) which communicates the power to the machinery employed. The wheel and the guide-plates are covered by a cast iron case or shell, and the wheel is kept in an exactly horizontal position by a special cover (D). The guide-blades are also rigidly kept in position by bell-cranks and coupling rods (E, E, E). The water having expended its force acting on the vanes at different points, passes out of the centre both above and below. The turbine may be placed close to an opening at the bottom of a tank or reservoir of water, or the water may be led by a pipe into the turbine which may be placed in the barn instead of at the foot of the tank. The velocity of the wheel depends upon the height of the fall. But even with a small fall the water has to squeeze its way in different directions between the guide-plates until it reaches the vanes of the wheel which it has to move before it can escape at the centre of the wheel above and below. In the figure the wheel inside the case is barely visible to the right of D, but the guide-plates are entirely hid from view.

159. The advantages of water-power over other forms of mechanical power are: (1) its constancy, (2) its inexpensiveness and (3) its simplicity. Water wheels and turbines do not require skill to drive them and they do not readily get out of order. (4) There is also less danger in using this mechanical power than any other. A hurricane may bring down the wheel of an aeromotor; steam may burst the boiler and the fuel may burn the fire-box. Men and animals also do many kinds of damage, and where their work can be wholly or partially replaced by the mechanical powers, work goes on more smoothly. The importance of having a farm near a flowing stream of water can never be overstated.

160. *Steam-power.*—Steam Engines which are employed in farming in highly civilised countries, are of three descriptions, *viz.*, Stationary, Portable and Traction. Multitubular boilers are now in general use. Ordinarily 2½ to 3lbs. of coal are consumed per H. P. per hour. Low power stationary engines are useful in farms for dairy purposes, *e.g.* for steaming food, pulping and grinding and working the centrifugal cream separator. Steam is most essential for keeping dairy utensils clean and free from germs. Portable engines are in more common use for ordinary farming. These are let out to farmers who use them for thrashing and winnowing their corn. The portable engines in general use are of 8 H. P. Traction engines which are more powerful still are used for ploughing &c. They are not yet popular even in England and we need make no further mention of them here.

161. *Gas Engines and Oil Engines* are worked on the same principle. In each case explosion results in the generation of gases which under ordinary atmospheric pressure occupy more space than the substance which exploded did before explosion. By keeping these gases controlled within a cylinder and preventing their expansion, pressure is generated on the walls of the cylinder. A piston inserted inside this cylinder moves exactly in the same way as the piston of a steam engine cylinder by force of the steam. Explosion of coal-gas is a well known phenomenon. In the case of oil-engines an explosive oil, such as Kerosine, is used. The oil is vapoured and ignited in the presence of air which is introduced into the vapouring chamber at the commencement of each stroke of the piston, —this resulting in explosion. As oil is far more conveniently carried and stored, than coal, oil engines are getting very popular for use in farms which are usually situated in outlying districts where cartage comes expensive. The actual expense is also less. In terms of coal, an oil-engine consumes an equivalent of less than 1½ lbs. per H. P. per hour against 2½ lbs. consumed by ordinary steam-engines. About

$\frac{1}{10}$th of a gallon of oil per H. P. per hour is required to work an oil-engine. The plant for generation of gas from coal is also expensive and oil engines are therefore more economical than gas engines. Oil and gas engines require less skill in management and they may be set in motion at less time, but they are, on the other hand, more liable to get out of order, having more little parts where soot may lodge, &c. Where sudden but temporary suspension of work causes great inconvenience, *e. g.* in electric lighting, steam engines are found more satisfactory than oil or gas engines, but in farm operations such occasional stoppage causes no particular inconvenience. The boiler and the firebox of a steam engine are expensive to renew from time to time as they have to be. Less water also is needed for working gas and oil engines, as the water is required only for cooling the cylinders. Gas and oil engines are particularly suitable for intermittent work. In working steam engines time is taken up in getting up steam and if this has to be done two or three times a day there is waste of resources. Steam engines are however very useful where the use of steam for heating, cooking, clearing and sterilising is of primary consideration as in a dairy-farm or a fruit-farm where jam and jelly are made on the premises. Except for such special purposes, a portable oil engine is to be preferred to a steam engine for farm use, where the owner has the means of introducing such forms of power.

162. *Electricity.*—This power is cheaper per unit than either horse, steam or any of the other forms of power we have been speaking of. The use of electricity in agriculture is, on the whole, still in an experimental stage. Electric lights are used for stimulating the germination and growth of plants. The use of electricity on a large scale for driving thrashing machines, chaff-cutters, kibblers &c., and even for ploughing, has been inaugurated by an association of farmers in Bavaria. The current which has a pressure of 5,000 volts, is generated partly by water-power and partly by

steam-power, at a distance of seven miles from the district in which it is utilized. In France also, water-power is utilized by means of turbines in generating electricity from dynamos attached to the turbines. Electric cables carried along from tree to tree supply power to homesteads where it is utilized either for tillage or for barn-door operations. Electricity has been most successfully employed for ordinary agricultural work in M. Plat's Estate at Enguibaud in the province of Tarn, and future developments in European agriculture are likely to be mainly in the electrical department. But the subject is too abstruse and remote for detailed consideration in this country, as yet, and we mention it here simply for giving the subject of motive powers a semblance of complete treatment. One point should be however borne in mind, that an Indian capitalist going in for farming should first look to a running stream of water for his ultimate motive power, whatever shape the motive power may take in course of time.

CHAPTER XII.

PLOUGHS AND PLOUGHING.

Indian plough.

THE Indian plough, consisting of a tongue of wood fitted with an iron tooth, a stilt for holding and a pole for attachment of bullocks, works the soil to a depth of only 3 to 5 inches. This primitive implement however varies very much in weight, size and form, and some are very much more effective than others. The Rungpur and Jalpaiguri ploughs which are least efficient scratch only about 2 inches of the soil, while the heavy Bundelkhand plough, weighing nearly $3\frac{1}{2}$ maunds stirs the soil to a depth of 9 inches or a foot. This latter implement is worked by 3 pairs of oxen and 9 men, and cultivators club together to use one another's bullocks in their fields. The Bihar ploughs generally are heavier and more effective than the Bengal ploughs, and they

work the soil to a depth of 5". The Cuttack and Noakhali ploughs are very heavy and the two sides of their body are shaped like two mould-boards, which give them the appearance of ridging ploughs. The ploughs of Saharanpur, Muzaffarnagar and Meerut districts are shod with a horse-shoe-shaped iron round the edge of the tongue and instead of a small iron tooth, are fitted with a long pointed bar of iron which projects out behind the heel, and which can be forced forward as it gets worn out. The 'share' of the Guzerat plough is arrow-shaped and it is fixed on a wooden sole. This share also can be pushed forward as it gets worn out.

164. *The defects of the native plough* are, first that it has no mould-board and it cannot in consequence invert the soil, secondly, that it makes V shaped furrows leaving ridges of unploughed land between, and thirdly, there is waste of power due to rudeness of construction. As a rule also, the native plough stirs the soil to a very slight depth and works only a bigha a day in place of 3 bighas or more which can be worked with ordinary English ploughs. English or American ploughs make rectangular furrows of wider width, and the upturned soil getting inverted the grass and weeds get covered up in the process of ploughing. As a rule, European and American ploughs are too heavy and too expensive. But a Swedish plough is habitually used in preference to all others in the Nagpur and Saidapet Experimental Farms and at Sibpur are used a ridging plough and a turn-wrest plough with a pair of ordinary bullocks. The bullocks of the C. P. and Madras being very much superior to Bengal bullocks the use of the Swedish plough is not considered objectionable. For heavy soils the Swedish plough is unsuitable especially for Bengal bullocks, but for light soils it can be tried with success where a better class of bullocks is available. The European double-mould-board plough or Ridging plough can be worked with success *on ploughed fields* even by Bengal bullocks. There

is some advantage in using this plough especially on heavy soil where sowing is to be done on ridges for rainy season crops or in furrows for the dry season, or where subsequent earthing is done as in the case of potatoes, groundnuts, sugarcane and mulberry. The ridges can be split and the earth thrown on the furrows when required, for covering seed potatoes, sugarcane cuttings, &c., or in the subsequent earthings.

165. *Deep ploughing* is done with ordinary native plough as also with superior ploughs, by one plough being passed behind another in the same furrow. Deep ploughing with cheap appliances can be done in another way also. The loose soil stirred by the first ploughing can be gathered in the dry season in two rows separated by 8 or 9 ft. by passing a heavy **A** shaped wedge of wood, which may be called the Meagher Dragger (Fig. 12), through the



FIG. 12.—MEAGHER DRAGGER.

ploughed field. The driver sits on one of the cross-pieces and puts his legs against the other cross-piece when he is driving the bullocks along. The interval can be ploughed afterwards and the loose soil heaped up on the sides then spread over. This method of ploughing in two layers may be utilised with great advantage in introducing sewage farming. The sewage

cart may be emptied in a very thin layer in the interval before the loose earth on the sides is spread over it. The deodorising effected is nearly complete. At least 2 or 3 months after the spreading of the sewage, if it is done between March and June, the land will be found perfectly inoffensive. The addition of a little lime makes the operation still more harmless. Colonel Meagher of the Allahabad Farm has introduced a similar system of sewage farming to what is here described.

166. Of the *improved ploughs*, the Meston plough may be mentioned as on the whole the raiyat's ideal of an Indian plough. It has been recently invented by the N.-W. P. Agricultural Department who have been experimenting for a number of years on various ploughs imported or constructed at the Cawnpore workshop. Its price is only Rs. 4. It is light and very easy to work. It has a mould-board and its depth is easily adjustable. It is useless for heavy soils. The Watt's Plough, also an N.-W. P. Agricultural Department plough, is stronger and more efficient, but its price is Rs. 7. The Sibpur plough is rather too heavy for ordinary Bengal bullocks, and its price is Rs. 7-8. Both Watt's plough and Sibpur plough can be used for ploughing heavy soils. Jessop and Co's 'Hindustani Plough,' Seeley's 'S. S. plough,' the 'Kaiser Plough' and the 'Baldeo Plough' of the N.-W. P. Agricultural Department, are other improved ploughs that may be mentioned here. The Baldeo plough which has also a mould-board like the other improved ploughs has been actually sold for Rs. 3 each, but it is too light, and inefficient and it is altogether unsuitable for heavy classes of soil. Of the ploughs tried at the Sibpur Farm, the soil of which is very heavy, the Sibpur plough (Fig. 13) has been found the most effective. It does a little over one-third of an acre a day (8 hours) at the first ploughing and a little over ½ an acre a day at the subsequent ploughings. The bullocks should be at least high class Bengal bullocks.

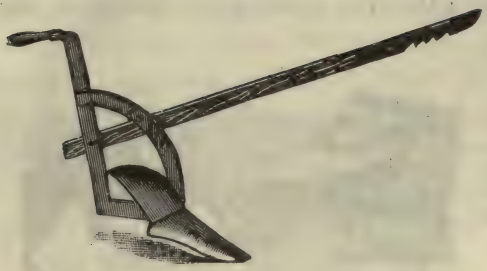


FIG. 13.—THE SIBPUR PLOUGH.

167. These improved ploughs not being provided with a double stilt, the steering of the bullocks can be done by the same man who holds down the plough. The Meston plough is so nicely balanced that it needs little effort on the part of the ploughman to hold it down, but, as already said, it is unsuitable for heavy soils.

168. *Principles of improvement.*—As there is no doubt we have not come to the limit of improvement in the manufacture of ploughs on rational principles for Indian raiyats, it is necessary to have a clear idea of the principles on which the construction of European or American ploughs is based, and of the character of the chief forms of these ploughs and the method of using them.

(1) The furrow-slices lifted by these ploughs are commonly rectangular in section (Fig. 14), but they are some-

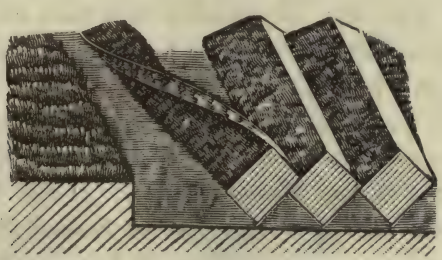


FIG. 14.—RECTANGULAR FURROW-SLICE.

times parallelogramatic and sometimes crested or trapezoidal (Fig. 15). The rectangular furrow is the best and

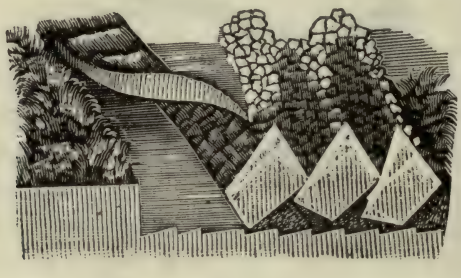


FIG. 15.—TRAPEZOIDAL FURROW-SLICES.

ploughs that turn up rectangular furrow-slices are the best, other things being equal. (2) The furrow-slices should be laid evenly at an angle of about 45° to the horizontal. (3) The depth to width should be as 7 : 10 (7 inches being the usual depth and 10 inches the usual width of a furrow made by an English plough). The objects of these angles and proportions are to expose the greatest surface to the action of air and to allow the harrow passing through the crests to form a proper tilth and seed-bed. When the width is too great for the depth, the furrow-slices lie flat and the harrow has not the same effect. If the depth is too great for the width the furrow-slices stand on edge and show a tendency to fall back. (4) There ought to be a coulter to give the vertical cut that the furrow-slice may turn over clean. (5) The mould-board should so curve backwards that it may not offer too great a resistance to the soil.

169. *European ploughs.*—The common forms in use in Europe and America are: (1) the Swing Plough, (2) the Wheel Plough, (3) the Double Furrow Plough, (4) the Three-Furrow Plough, (5) the Paring Plough, (6) the Subsoil Plough, (7) the Subsoil-stirrer or Subsoiler, (8) the Ridging or Double-mould-board Plough, (9) the Pulverising Plough, (10) the One-way

Plough including the Turn-wrest or Turn-wrist Plough, and the Balance Plough, (11) the Sulky Plough, (12) the Potato Digging Plough, and (13) the Steam Ploughs. We will now shortly go through these that one may judge for himself whether any of these or any portions of these can be introduced with success in this country. As the wheel-plough is practically a swing-plough with wheels put on, the same figure (Fig. 16) will answer for illustrating both the ploughs.

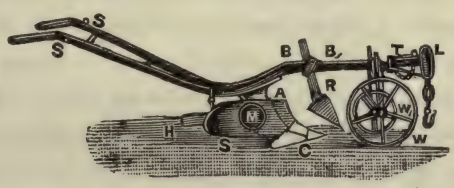


FIG. 16.—WHEEL-PLOUGH.

170. *The Swing-plough* consists of the following parts: (1) The Body (A), or frame to which other parts are fixed. (2) The Sole, Bottom, Slav, or Plough-ground (S) is the part to which the share or cutting part of the plough is attached, (3) the Share or Sock (C) which is often made of wrought iron, when it can be relayed when damaged. For shallow stony soils shares are made more pointed and slightly bent downwards. It is usually fixed at an angle of 7° from the ground to prevent its yielding. For soft or clay soils the shares are made wider. Shares are sold separately for 10*d.* or a shilling each. Cast-iron shares are more common and they are harder. (4) The Heel (H) is the posterior part of the sole which the ploughman uses as his fulcrum in turning or raising the plough. (5) The Beam (B.B.) is the front portion of the plough between the Body and the Bridle. (6) The Head (T) is the front end of the Beam to which the Bridle (L) is fixed. (7) Bridle or Hake (L) by which the depth of the furrow is regulated in the swing-plough. (8) The Coulter (R) or knife which is fixed to the beam and which gives the perpendicular cut to a furrow-

slice, slants slightly forwards. It can be easily removed like the share for sharpening or relaying, or replacing. For stony soils, coulters like shares are made of wrought iron or steel. but they are ordinarily made of hard cast-iron (chilled iron). The coulter-blade is $2\frac{1}{2}''$ to $3''$ wide, and fixed at an angle of 65° to the share in wet weather, but at a smaller angle and more forward in the dry weather. Using the plough on fallow ground the coulter should point a little behind the point of the share. The coulter has usually a hole in it from which suspends a chain and a small iron ball which presses down long grass or dung as the furrow is being turned, so that these may be better covered. A sharp revolving disc-coulter is used on grass land or level lawns where there are no stones. (9) The stilts (SS.) terminating in wooden handles to hold by with both hands. (10) The Mould-Board (M) is joined on to the right of the body behind the shoulder of the share and it is so modelled, that it turns over the soil clean. The mould-board is kept smooth and clean and not loaded with earth which would give obstruction in working and thus add to the draught. (11) The Cheek-plate is just below the land-side of the body, *i.e.* opposite the mould-board, and it slides against the unploughed land. In the figure this part of the plough is not visible. The *weight of a swing plough* is 3 to $3\frac{1}{2}$ maunds and it costs in England 4 to 5 guineas.

171. The *Wheel-plough* resembles the swing-plough, but it has two wheels (W & W) attached to the beam (B) by means of two sliding bars or uprights coming down from the beam. One of the wheels (W) called the furrow-wheel marches along the bottom of the furrow and the other (the smaller one) called the land wheel, (W) along the unploughed land to keep the plough in position. The lower end of the larger wheel should be adjusted at the same level with the sole. If one wants to make the furrow an inch deeper than one has been getting, one raises the land-wheel (*i.e.* the small wheel) an inch, and if one wants to make the furrow an inch

shallower he sinks the small wheel an inch down. In the case of the swing-plough the experienced ploughman adjusts the depth by raising or lowering the bridle. The beam in the case of the wheel-plough is a little curved towards the furrow side, and the line of draught is a little higher than in the case of the swing-plough as the depth is automatically adjusted by the difference between the diameters of the two wheels. There is usually a second coulter called the skim-coulter in front of the ordinary coulter which skims dung &c., and spreads them out. The wheel-plough though heavier and costlier (about £6 to £8 being the price in England), is lighter in draught and it is easier for the man also to work it. Shallow ploughing can be done more easily with the wheel-plough, which regulates depths to a nicety, than with the swing-plough. The swing-plough requires to be handled by expert ploughmen. But there is waste of time in adjusting the depth in the case of the wheel-plough. In the hands of a good ploughman the swing-plough works at different depths with sufficient evenness for all practical purposes. Then the wheels get clogged in wet weather; and for steep and rough (*i.e.* stony) soils, the wheel-plough is unsuitable. The cost of a wheel-plough is also prohibitive for our cultivators, though where the land is suitable and where the workmen are not clever, the wheel-plough comes cheap in the long run. Besides, the wheels with the axle-bars and uprights may be taken off and the plough used as an ordinary swing-plough. A swing-plough of very much simpler construction but containing all the essential parts, *i.e.* the share, mould-board, coulter and an adjustable bridle, ought to be introduced into this country. The advantage of wheel-plough over swing-plough in traction is 10 to 15 per cent. In the swing-plough the share and the coulter absorb 44 per cent. of the friction or resistance, the sole 15 per cent., the cheek-plate 35 per cent. and the mould-board 6 per cent. The directions of resistance are in three planes: (1) the perpendicular

resistance which passes through the plough nearer the land than the furrow side; (2) the horizontal resistance which is along the sole-plate and (3) the curved resistance which follows the course of the outer surface of the mould-board.

172. *Draught.* —The weight of the plough in the case of European and American ploughs contributes from 34 to 50 per cent. of its draught. The shape of the mould-board also affects the draught considerably, but the depth and width of the furrow and the nature of the soil chiefly influence the draught. A long and gradually curved mould-board offers the least resistance, a point which is generally overlooked in the construction of improved ploughs for India. Dry clay soil offers very strong resistance, if the mould-board is not of the right shape. The draught of ploughs, harrows and other implements is *measured* by the dynamometer which is only a spring-balance of a special construction. The draught of Madras ploughs has been found to vary from 280 to 390 lbs. Some experiments conducted at the Cawnpore Farm showed that draught of ploughs for up-country bullocks should not exceed 126 lbs. Madras bullocks are very much superior to up-country bullocks, and these latter are somewhat better than Bengal bullocks. The draught of a plough in Bengal should not exceed 100lbs. The draught on fallow land is considerably higher than that in tilth, and it is therefore easy with a country or an improved plough to plough half-an acre a day when ploughing for the second or third time, though it is difficult to do one-third of an acre at the first ploughing. With a wheel or swing plough as much as one acre can be ploughed per diem.

173. As the draught for ploughs used in Bengal should not exceed 100 lbs. and as the dead weight of a plough properly constructed should account for only 34 to 50 per cent., or say, about 40 per cent. of the draught, the ordinary swing-ploughs or wheel-ploughs which are over 300 lbs. in weight are clearly unsuitable for use in this country, though a strong

pair of bullocks can work the plough for a few days or only for a few hours at a show-yard, to apparent satisfaction.

174. *Swingles and Yokes.*—A plough or any other cultivating instrument is attached in European countries to horses or bullocks by means of a Swingle or Whipple-tree or trees and ropes or chains. The yoke to which the further ends of the chains or ropes are attached may be only a single piece of wood going across the necks of the animals, or the fraction at the hump may be lightened by having another piece of wood for chest with cross pieces to keep the two in position. The chain or rope to which the whipple-tree is attached is called the draught-rope. The yokes are made of wood with curved notches for the necks of the animals. Yokes furnished with breast-beams (Fig. 17) are used in some provinces. These distribute the resistance to a greater surface and thus lessen the occurrence of yoke-galls. The Bengal method of yoking



FIG. 17.—YOKE.



FIG. 18.—SWINGLE FOR ONE ANIMAL.

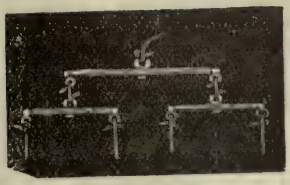


FIG. 19.—SWINGLE FOR TWO ANIMALS.

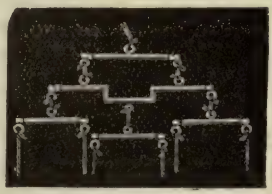


FIG. 20.—SWINGLE FOR THREE ANIMALS.

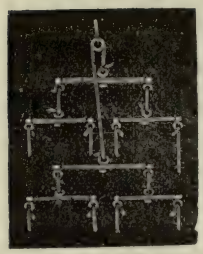


FIG. 21.—SWINGLE FOR FOUR ANIMALS.

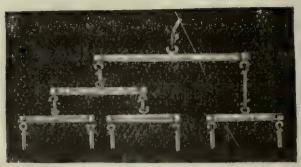


FIG. 22.—SWINGLE FOR THREE ANIMALS. (Another pattern).

on two sides of a long pole rigidly attached to the plough has the advantage of simplicity and cheapness. It does away with the necessity of reins also, bullocks being guided by a touch or twist of the tail with one hand while the single stilt is held by the ploughman by the other. The improved ploughs recognise the advantage of this simplicity and cheapness. Figs. 18, 19, 20 and 21 illustrate the method of attachment of one, two and three animals respectively to an implement. Fig. 22 illustrates another method of attaching three animals.

175. *Multiple ploughs.*—Two furrows are turned simultaneously with a Two-furrow-plough instead of one. The draught is therefore much greater, and as three horses are required to drive this plough, it is clearly unsuitable for Indian bullocks. Having a wider bottom it does as even and steady work on level soils free from stones, as the wheel-plough. There are no side-plates or sole in this plough and it does not therefore form pans. For preparing seed-bed on ploughed land two horses can easily manage this plough. It does twice as much work as the wheel or swing plough. The three-furrow plough turns 3 furrow-slices at the same time, each 9″ wide, and it can plough 3 or 4 acres of land per day if the soil is very light. Having a wide-bottom, the draught is very heavy and 4 horses are required for drawing

it. The price of the Double Furrow Plough is £7 to £10, and of a Three-Furrow Plough as much as 12 guineas. These ploughs ore altogether unsuitable for Indian needs.

176. With reference to multiple ploughs, however, may be mentioned the *seeding plough* of Messrs. Hornsby & Sons, Grantham (England). This implement can be used either with or without the seed-box. Without the seed-box (Fig. 23) it may be used for simple ploughing (3″ or 4″ deep only) or for covering the seed after it has been broad-casted. It

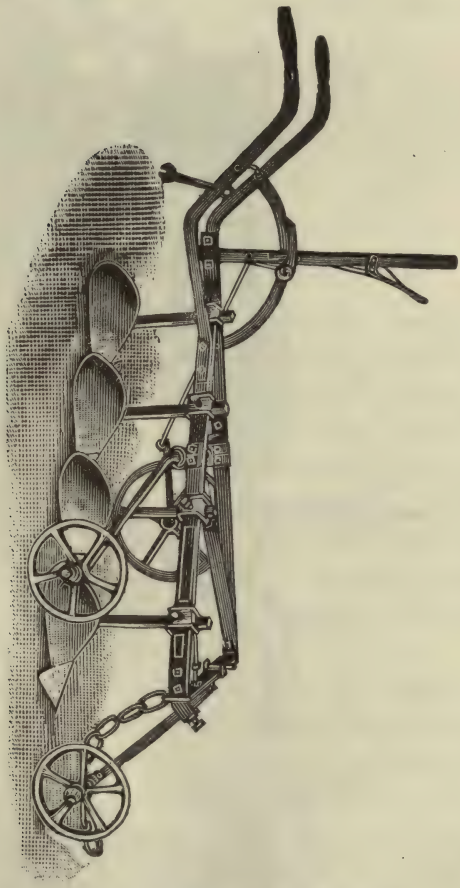


FIG. 23.—MULTIPLE PLOUGH.

can be regulated to any depth up to 4 inches and in width to 6½ inches for each furrow. It is well within the power of a pair of light horses to do the work, as it is carried on three wheels. Best chilled iron is used for the shares, and all the wearing parts are easily renewable. Equipped with the seed-

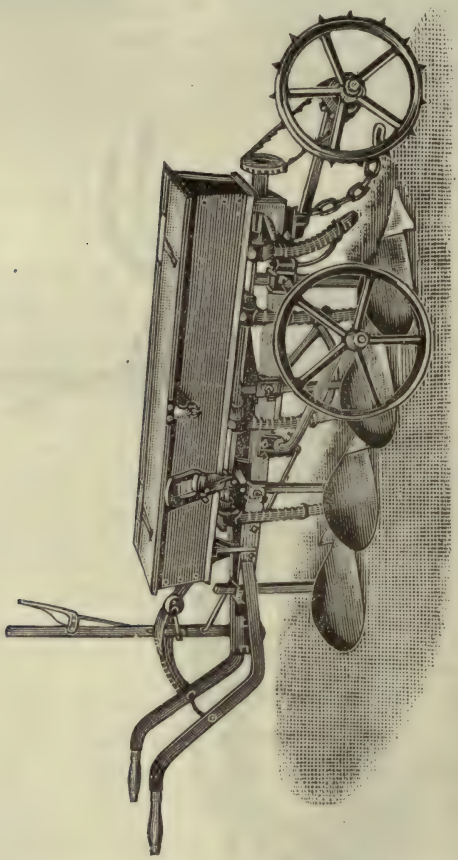


FIG. 24.—SEEDING PLOUGH.

box (Fig. 24), it sows the seed directly into the furrow efficiently, covering it at the same time. The quantity of seed sown per acre is controlled to a nicety by the simple move-

ment of an indicating lever. The Four-Furrow Improved Seeding Plough with seed-box and conductors complete is priced at £7. This plough, used not for the first ploughing but for subsequent operations and specially for sowing, may have a very important future before it, if capitalists go in more largely for agriculture in this country.

177. *The paring plough.*—The paring plough is an ordinary wheel-plough fitted with a share 12″ broad. It is used for doing very shallow work, and the wheels are adjusted so as to turn up slices 1″ or 2″ deep. The Deccan Bakhar



FIG. 25.—THE BAKHAR.

(Fig. 25) can be used as a paring plough, either for stifle-burning sods or preparing a seed-bed on ploughed up land which is fairly dry. The Bakhar does not work in wet clay land for preparing seed-bed. For ploughing wet fallow land 2 or 3 inches deep, for destroying weeds, and for preparing a fine tilth on fairly dry soil, the Bakhar is a very valuable though inexpensive implement. The knife of the Bakhar is made about 2 ft. long and with a pair of strong bullocks one can prepare 2 or 3 acres of land for tilth and at the same time destroy the weeds.

178. The *Subsoil plough* is like an ordinary single furrow plough, but of stronger construction, having a deep body and a large mould-board. It is used behind an ordinary swing, or wheel-plough along the same furrow, and it turns up the subsoil. It is used only where the subsoil is known to be better than the surface soil. Requiring two pair of horses it is clearly unsuitable for Indian use.

179. The *subsoil stirrer* or sub-soiler (Fig. 4) moves the subsoil without turning it up. This is also used behind an ordinary plough. It has no mould-board and it can hardly be called a plough. It moves the soil 12″ to 18″ deep. A subsoil stirrer is sometimes attached to a strong wheel-plough on the right side and in a line with the point of the share. It passes along the bottom of the furrow raised and moves it. A subsoil plough on wheels adapted for light soils costs 7 guineas and for heavy soils 10 guineas.

180. The *Ridging or Double-mould-board plough* (Fig. 2) is made like a swing or a wheel plough. It has a mould-board on either side, but no coulter. The mould-boards are shorter and nearly flat. It is used for making ridges and splitting them, also for splitting drills for sowing turnips, potatoes &c. A marker is hinged on to the beam of the ridging plough. It marks on the ground the line where the next ridge is to be. The marker is held in position by a chain. By another chain behind, the ploughman can turn the marker on either side of the plough. The cost is £4 and £1 extra for wheels.

181. The *pulverising plough* breaks up but does not turn over furrows. The Indian plough and the Subsoiler may be regarded as pulverising ploughs, and the improved ploughs as simple swing-ploughs.

182. The One-way-plough.—With an ordinary plough ploughing cannot be done line after line in succession, as the slices are turned one way during the forward march and in the opposite way during the return march. The whole of the land cannot in this way be both ploughed and turned over. With the one-way-ploughs, of which one form is called the Turn-Wrest or Turn-Wrist plough, and another the Balance Plough, furrow slices are all laid side by side one against another in the same direction avoiding open unploughed furrows and ridges covered by furrow-slices. There are two sets of mould-boards and shares in the Balance Plough. When one set is at work on one side, the other set is kept raised on

the other side. At the end of the field the position is reversed, the set which was kept raised being now brought into action, and the plough is turned in the ordinary way as a carriage is turned. In the Turn-wrest plough there is only one set of share and mould-board which are reversible round a hinge while in the Balance plough there are two sets. In ploughing hill-sides the ordinary system of ploughing round and round a field is unsafe, as the bullocks are liable to go down the precipice or get choked with the ropes with which they are attached to the yoke. It is safer in hill-side ploughing to take line after line in the lateral direction only. If cross-ploughing is done at all, the bullocks should not be made to plough up-hill but simply walked up and the down-hill ploughing if no terraces have been made should be done with the greatest care. Turn-wrest ploughs can be easily introduced into India, as the cost would not be prohibitive and it is easily driven by a pair of bullocks.

183. The *Sulky plough* is used in American prairies. The ploughman sits and drives and covers 5 acres a day. 2 furrows 3″ or 4″ deep are turned over at the same time. It is driven on light but strong wheels almost as fast as a carriage is driven. For perfectly level prairie land it is a very useful kind of plough.

184. The *potato digging plough* is fashioned like an ordinary plough; but it has two shares, one behind the other, both elevated posteriorly and divided or forked. The shares are driven in underneath the ridges to turn out potatoes. The *Potato-digger* by Story and Son of Jedburgh, Howard and other makers, is not exactly a plough. It consists of a strong frame-work run on 4 wheels, the 2 front ones being smaller than the hind ones. A broad sharp share passes underneath and lifts the potato ridges while a set of 8 revolving forks working at right-angles to the ridges above the share is worked by the hind wheels. This is put on or off gearing

at will. It throws as the digger advances all the earth and potatoes from ridges on land that has been cleared, against a screen which keeps them from spreading far and wide. This bruises the potatoes to a certain extent, but when a canvas screen is used hardly any loss occurs. Potatoes are gathered carefully each time, else they get covered up. When potatoes do get covered up, they can be harrowed up again, but constant knocking about especially with harrows reduces the value of potatoes and makes them liable to putrifaction. On light land two horses can work the potato-digger, but on heavy soil, 3 are required. 4 acres can be dug out in a day. The cost of a potato-digger is £12 to £13. On heavy or wet soil it does not work satisfactorily. The work done by a potato-digger leaves the soil beautifully fine and mellow and free from weeds. The remains of the weeds and potato-haulms can be easily raked off and the land used immediately afterwards for growing sugarcane, maize, *jowar*, groundnuts or *arahar*. The potato-digger can be used also for digging out groundnuts and yams of different kinds. The implement is unsuitable for the Indian *raiyat*, but a capitalist going in for growing potatoes or groundnuts on a large scale will find the outlay effecting great saving in the cost of hand-picking. Four strong bullocks must, of course, be employed attached to a proper swingle.

185. *Steam ploughs* have been found utterly unsuitable for Indian surroundings. They have been tried by Mr. Archie Hills of Patkabari (Dt. Murshidabad) and by Mr. Armstrong of Dehra Dun, and others also. Skilled supervision and the first outlay cost more in India than in England, and the advantage of steam-plough over horse-plough even in England is only as 10 : 9. Where Englishmen have taken to farming on a large scale, *e.g.*, in the Fiji Islands, and where labour is dear and labourers scarce, steam ploughs are found of great use. At the first ploughing, the furrows are made 12″ deep ; at the second ploughing 15″, and at the third ploughing 18″, and

thus the ground disintegrated in a far more thorough manner than is possible with any other plough.

If one were asked to judge a competition in ploughing, one should mark the following points :—

(1) Whether the furrow-slices are clean cut on land side and the bottom.

(2) Whether they are laid regularly and compactly one against another at an angle of 45°.

(3) Whether grass, stubbles and weeds are turned in and covered.

(4) Whether the upper ages of the furrow-slices are on a level, so that an even seed-bed may be formed by harrowing.

(5) Whether furrows are straight and finished regularly at the ends.

(6) Whether the "Hintin-Furrow-slice" or the last furrow-slice, is properly turned out and about the size of the rest.

(7) Whether the depth has been regulated according to the nature of the soil and the crop to be grown and for the time of the year, 4″ to 9″ being the limit for this country.

(8) Whether the proportion between depth and width of the furrow-slices tuned over is as 7 : 10.

186. To understand the *English system of ploughing*, it is necessary to comprehend a number of technical terms. These are (1) Crown, (2) Open furrow, (3) Gathering, (4) Splitting, and (5) Feering.

(1) The 'Crown' is the highest line of the ridge, running up the middle of one unit of a field under tilth, all the furrow slices sloping up towards it.

(2) The 'Open-furrow' is the depression between two ridges, the furrow-slices slanting away from this.

(3) 'Gathering' is the name given to the system of ploughing in which the horses always turn towards the crown. When ploughing round and round by 'gathering' goes

on in a field for some years, the field begins to have a wavy appearance, the hollows being 'open-furrows' and the elevated portions 'crowns.'

(4) 'Scattering,' 'Splitting' or 'Scaring' is the name given to the system of ploughing in which the horses always turn away from the crown.

(5) 'Feering' is the marking out of land for the first time into sections, or units of tilth, by means of 'feering poles,' indicating where the future 'crowns' are to be. The width is fixed upon by the foreman or the first ploughman, a width of either 33 ft. or 66 ft. being chosen. Narrow width (16½ ft. or 33 ft.) involving close ridges, is best suited for stiff clay lands inclined to be wet and which are benefited by surface drainage. A feering-pole is 8¼ ft. *i.e.* ½ a perch in length. Four or more feering-poles are used when a field is brought under plough for the first time or where no ridges and open furrows are observable for some reason (*e.g.* after harvesting a green crop), or where the old ridges are not to be kept up. In very old fields which have been long under plough lines of the old 'open-furrows' are followed to replace them by 'crowns,' 'gathering' being done round and round the 'open-furrows' instead of the crowns. This serves to keep the crowns down as low as possible. The two first slices are also cut thinner than the rest to keep down the crown.

187. *Method of ploughing.*—It is along the future crown that the feering poles are set up. The line along the poles is first ploughed up (to get all the land moved), first one way and then in the reverse way, so that a double furrow is left at the crown and the two slices turned one one way and the other the other way. In setting up the feering-poles half the distance desirable between two ridges is measured from the end of the field, and the feering poles set along this distance. The line along the poles is ploughed as described, and then the poles removed to the full distance between two ridges. This line along the poles where they are removed, is also

marked out by the plough as above, and the poles removed to the full distance between the ridges again and the operation repeated until the whole field has been marked out. The ploughing is done round and round these lines by gathering. The horses turn at the headlands which should be fairly broad that no difficulty may be experienced by horses in turning at the ends of the fields. If headlands are left on all sides these may be ploughed up afterwards by driving the plough round and round the field away from the fences and not towards them. When feering poles are set up at the full width between ridges to start with, ploughing is done by splitting. With a $8\frac{1}{4}$ ft. staff, 66 ft. or 33 ft. may be easily measured and an acre being 660 ft. × 66 ft., these widths are convenient for making mental calculations as to area. Light soil should not be made too wavy by ploughing. Sections of 132 ft. may be taken for each gathering on such soil.

188. *Principle of calculation.*—A man ploughing an acre and turning over furrow-slices only an inch wide would turn over 99 miles of furrow-slices. If he ploughed 12″ wide he would cover $\frac{1}{12}$th this distance, *i.e.* 8·25 miles. If he ploughed up 6″ slices he would cover $16\frac{1}{2}$ miles in a day if he succeeded in doing 1 acre. With an ordinary country plough, or with an improved plough the utmost width obtained is 6″, and as $16\frac{1}{2}$ miles of walk while ploughing is too much for the ploughman, $\frac{1}{3}$ of an acre which involves a walk of over 5 miles while working should be considered a good day's work for a ploughman, at least for the first ploughing. Attempt should be made to get the plough-man to do 5 or 6 miles of walk per day while ploughing. To get the number of miles walked in ploughing an acre it is only necessary to divide 99 by the breadth of the furrow (in inches) turned out by a particular plough. With ploughs of different widths of share turning out different widths of furrow-slices, the ploughman should show different quantities of work.

Expert opinions.—With regard to the possible improvements that may be introduced into the native system of ploughing &c. in India, the following remarks of Dr. J. A. Voelcker recorded in his Report on the Improvement of Indian Agriculture are worth noting :

"I cannot help suspecting that the system of shallow ploughing, as practised by the Native, and his aversion to ploughs that turn over a broad slice and form a wide furrow, may have something to do with this matter of the retention of moisture, and that the effect of deep ploughing would too generally be to lose the very moisture the cultivator so treasures"—(p. 43).

"After seeing for myself what is used, and what have been suggested for use, I am obliged to conclude that there is not much scope for improved implements under existing conditions"—(p. 217).

"Even if a thing be good in itself, patience, perseverance and energy are required to make the Native comprehend its advantages, but when once he is thoroughly convinced of its utility he will not be slow to follow it up. It took several years of waiting before the Beheea Sugar-mill began to make its way, but when once it was introduced into a District the demand for it often exceeded the supply"—(p. 217).

189. With regard to the relative merits of Watt's Plough and the country plough, Dr. Leather says : "At Cawnpore an improved plough having an iron share, and ploughing 5" deep, has been tested against the country-plough since 1881. Six years' experiment, during four of which they were made in duplicate, showed with one exception, a distinct increase in the cotton crop ; and eight years' experiment, of which seven years' were in duplicate, and in which wheat was the crop, showed, with one exception, an increase apparently due to the improved ploughs. Leaving out of consideration the actual increase obtained, which varied considerably it

must be remarked that assuming no effect on the crop, there is still a saving of half the labour. The improved plough is drawn perfectly well even by a small pair of bullocks, and the number of ploughings necessary is reduced to half."

190. With regard to the relative merits of the country-plough and the Sibpur plough, the following remarks of Mr. B. C. Basu regarding experiments conducted at the Dumraon Farm deserve attention :—

"To compare the soil-inverting with the country-plough, two plots, each 800 sqr. yds (a little over 5 local cottahs), were ploughed up and both cropped with wheat, and treated exactly alike in all other respects. The cost of cultivation was the same in both plots. The increase in outturn obtained by means of the inverting plough over the outturn obtained with the country-plough is shown below :—

Year.	Grain per acre.			Straw per acre.		
	Increase.		Decrease.	Increase.		Decrease.
	Mds.	Srs.		Mds.	Srs.	
1885-86 ...	2	16	...	3	21	...
1886-87 ...	1	14	...	1	8	...
1887-88 ...	1	35	...	...	...	0 14
1888-89 ...	1	4	...	1	35	...
1889-90 ...	2	4	...	4	16	...
1890-91 ...	0	30	...	0	19	...
Average ...	1	24	...	2	10	...

"The effect of soil inversion was equally conspicuous on paddy. The trial with this crop was carried out exactly in

the same way as with wheat. The results are shown in the following statement :—

Year.	Increase of grain per acre.		Increase of straw per acre.	
	Mds.	Srs.	Mds.	Srs.
1886 ...	1	6	9	16
1887 ...	0	35	2	38
1888 ...	1	8	2	8
1889 ...	3	1	6	2
1890 ...	0	24	3	20
Average ...	1	15	4	33"

CHAPTER XIII.

OTHER CULTIVATION APPLIANCES.

THE *Grubber.—The ordinary Cultivator* or *Grubber* is a simple enough instrument for Indian use. A five-tined grubber with duck-foot coulters, mounted on two wheels can be easily worked by two bullocks on land already ploughed and reploughed, once one way and the second time across. The advantage of using the grubber consists in the fact, that it stirs the soil to a varying depth of 5″ to 9″, uprooting and dragging weeds and coarse grasses before it. It stirs the soil deep without turning it up. The practice of smashing up land by cultivators instead of systematic ploughing has greatly increased in England and we can take the hint in this

country. The grubber used on the Sibpur Farm (Fig. 26) can be easily made in country places in India, and the cost need not exceed Rs. 20. The price of the 'Madras Grubber' is only Rs. 17. For early preparation of land for *Rabi* crops, for which quick and at the same time deep cultivation is desirable, the Grubber is an invaluable implement. It forms no pans. Grubbing should not be done in the *Kharif* season.

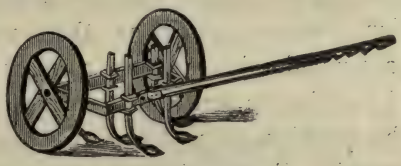


FIG. 26.—THE GRUBBER.

192. The *Harrow*.—These are either rectangular (Fig. 27) or circular. The frame of the rectangular harrow is several feet wide and long. It is usually divided into 2 or 3 sections carrying equidistant teeth usually 8 to 10 inches long which serve to break the surface clods after the plough or grubber has been used, in order to bring up clods to the surface to be afterwards smashed up by the roller, and to detach weeds from land which has been stirred. It is also used after the seed has been sown, to cover it. Chain-harrows, constructed

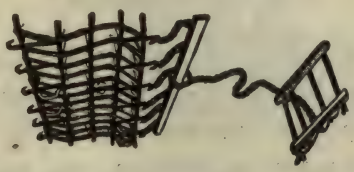


FIG. 27.—THE HARROW.

as a coarse coat of mail, are composed of plain, circular, or polyhedral rings, toothed rings and tripods, the latter connected by rings or links, the teeth being longer on one

side than on the other, so that either surface of the harrow can be used as the nature of the land or meadow requires. They are serviceable for light action, as when seeds require to be lightly covered or when manures require to be spread on grass land. The ladder, or beam, or levelling board used in this country takes the place of harrow, but the latter is a far more efficient implement especially for uprooting weeds and the lighter kinds can be used with bullocks. Heavy circular harrows, such as the cross-kill roller or clod-crusher, are unsuitable for this country on account of their cost and heaviness; but as even a chain harrow would cost Rs. 40, the question of replacing our beams and ladders by harrows may be dismissed for the present. Iron toothed harrows called *Bidias* are in common use in India and under existing circumstances it is hard to replace this. Steel rakes (Fig. 28) may be used like *Bidias*. A 15-teeth garden rake would cost only about Rs. 3.



FIG. 28.—HAND RAKE.

193. *Rollers* are useful for obtaining a level and compact seed-bed in which moisture is better retained. But they are too unwieldy and expensive for Indian use. Levelling boards and beams are in common use, especially in south India, and they answer the purpose fairly well. But a light wooden roller would be preferable.

194. *Seed-drills.*—When the soil has been prepared by ploughing (and cultivating or grubbing in the *rabi* season), harrowing and levelling, it is ready for sowing. Sowing

is done either by scattering the seed broadcast, or by drilling, or by dibbling. By dibbling the greatest economy of seed is effected, but it is a slow process, and if the seed is not perfect and germination is partial, too many blanks may be left. Dibbling is sometimes done when large sized seeds, such as *arahar*, maize and cotton, of reliable germinating quality, are sown, two in each hole. Smaller seeds should be either broadcasted or drilled. Broadcasting in experienced hands does not involve much waste of seed, nor irregular sowing and it is the cheapest way of sowing. But drilling is the most desirable system, as it does not require an expert hand, and as its application enables one to employ the bullock-hoe and hand wheel-hoe, saving cost of weeding and enabling one to keep the land stirred and aerified. The English and American seed-drills with 8 or 12 tines would be too expensive as the arrangements of these drills are too elaborate. The Madras Three Tined and Six Tined (Fig. 29) Seed-Drills and the *Surtha* or seed-drilling bamboo cylinder

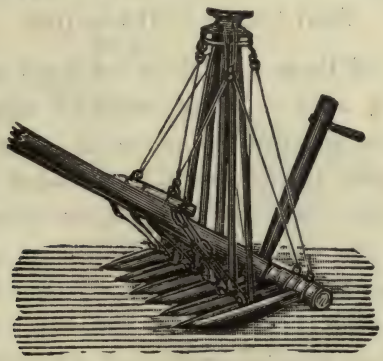


FIG. 29.—MADRAS TINED SEED-DRILL.

with a funnel shaped hopper at the top, are well adapted for the existing stage of native agriculture. When seeds for a mixed crop, such as *arahar* and cotton or *joar* and *arahar*, or maize and cotton, are drilled, the hopper of the 3 or 6 tined seed-drill with one hole stopped is fed by one person, while the

surtha dragged behind is fed by another person. Not being provided with wheels the native seed-drills require experienced plough-bullocks and ploughmen to work them and it requires long patience to introduce them successfully in a new locality. On the whole, perhaps, the one-furrow garden drills of American make (Fig. 30) have the best prospect of success in India.

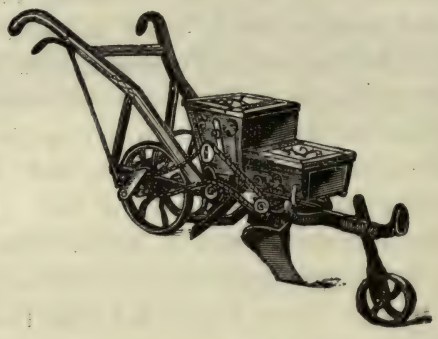


FIG. 30.—HENDERSON CORN PLANTER AND FERTILIZER DISTRIBUTOR.

195. Some of these hand drills are fitted with two boxes, one for holding seed and the other for some concentrated fertilizer such as super or sulphate of ammonia &c. Fig. 30 illustrates the Henderson Corn Planter and Fertilizer Distributor. One can sow with this 10 acres of land per day, dropping the seeds at any distance apart and sowing at the same time, if needed, any kind of pulverized fertilizer. Each machine is furnished with four dropping rings and pinions to regulate the number of seeds and distance apart of sowing. Extra rings are also supplied for sowing peas, beans and other special sized seeds. The price with the fertilizer box is 18 dollars, each extra ring costing 25 cents. Without the fertilizer box the price of the Henderson Corn Planter is only 14 dollars in New York. Planet Jr. Seeder No. 5 (price 12 dollars) is also recommended.

196. *Hoes.*—When seed has been sown and the young plants have come up, one hand-weeding with *khurpies* is necessary for most crops. Afterwards the soil between the rows of plants should be kept stirred and clean as often as convenient,—say once a fortnight or once a month, according to circumstances—until the plants are about 1½ ft. high. 2 or 3 hoeings give the crop a very good start and the land is also left clean. With an American wheeled hand-hoe (Fig. 31) one



FIG. 31.—AMERICAN HAND-HOE.

can easily work 1 bigha a day. With a bullock-hoe (Fig. 32) however, 1 acre a day can be done. The use of the hand-hoe or bullock-hoe presupposes the use of a seed-drill. The

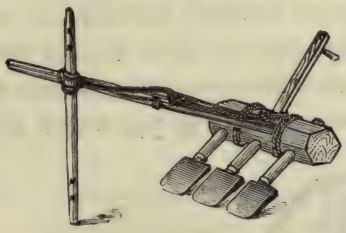


FIG. 32.—MADRAS BULLOCK-HOE.

Planet Jr. hoe (Fig. 31) may be used as a seed-drill, or hilling plough, or rake, by substituting one working part by another. A hand-hoe of the American pattern can be constructed for less than Rs. 10. The essential parts are, (1) 4 curved tines screwed on to (2) a bar with a slit in the middle, along which the tines can be arranged close together or somewhat apart from one another according to the width of the drill, (3) a

wheel going in front of the tines which serves as a guide, and (4) a double handle for the labourer to push the implement with. If instead of 4 tines only one tine is used or two tines at the two extremities of the slit, the furrow or the two furrows made by the implement may be sown with seed by a man walking behind who can cover up the furrows with his feet as he walks along.

197. Madras or C. P. *Bullock hoes* cost only Rs. 5 or Rs. 6. It requires trained bullocks to work these hoes straight. There is always a little damage done by the feet of cattle. The cattle must, of course, be muzzled. The use



FIG. 33.—THE C. P. DUNDIA.

of the hand-hoe is accompanied by no loss if the rows and lines are regular. Where the distance between two rows of plants is sufficiently great a Dundia (Fig. 33) which is a C. P. Bullock-hoe with a single knife may be used. But the combined hoe and rake (Fig. 34) which is used in the vine-

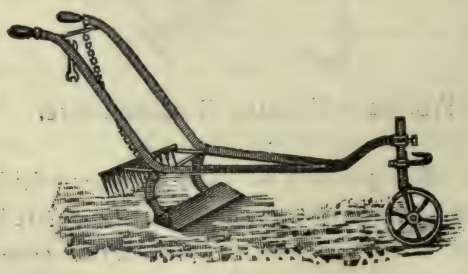


FIG. 34.—FRENCH COMBINED HOE AND RAKE.

yards of Europe, is a more effective instrument for this purpose. For hand-weeding besides ordinary *khurpies* and

niranies certain special forms of weeders (Fig. 35) called Eureka Weeder, Hazeltine Weeder and Excelsior Weeder, have been found very useful.

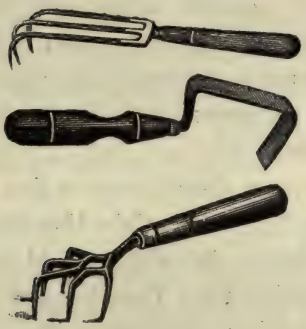


FIG. 35.—HAND-WEEDERS.

198. Mowers and reapers are unsuitable for Indian farming. The machines are too heavy and expensive and the fields in India are too small. Labour being cheap the harvesting sickle must hold its own for a long time to come, as the cost of harvesting is comparatively small. But there is no reason why our labourers should not be trained to use the scythe, which does far more work than the reaping hook (*kachi or kastia*).

199. *Threshers.*—Steam-threshers are unsuitable for Indian husbandry. But hand-threshers could be introduced with success by middle-class men wishing to launch out in farming. Even flailing is a better mode of separating the grain from the straw than treading the corn by bullocks. The bullocks voiding excrements on the straw and grain they tread upon, the system is decidedly objectionable. Instead of flails with wooden handles and leather thongs, flails could be improvised of green bamboos about 8 feet long, 1½ft. of which can be left cylindrical for the handle and the rest made semicylindrical and cut into three strips. Only the ears of

grains should be gathered and the heap of ears beaten with 3 or 4 flails by as many men and the heap stirred and formed again and again and beaten upon until separation of grains from the ears is complete. Beating bunches of straw with grain on boards is another clean and simple method of threshing which is in vogue in some parts of this country. But with the flail work is executed faster and it can be applied to all sorts of crops including pulses for which the beating board is unsuitable.

200. The European Handthreshers that have been found useful are: (1) Mayfurth and Co's Handthresher price Rs. 85, exclusive of freight &c. which would come to another 50 (2) Ransome's Bullock-Power Thresher and (3) Rustom Proctor and Co's Threshing machine. The first is obtainable of Messrs. Mayfurth and Co. of Frankfort-on Maine, Germany and it can be ordered through any local European firm who deal in argicultural machinery. It is used at the Nagpur Experimental Farm, where it is found to thresh 3½ maunds of grain per hour. It is kept working by 5 labourers. It is well-made, strong, compact and simple in construction, consisting of a revolving drum on which are fixed strong iron spikes which pass in close proximity along a series of spikes fixed on a curved plate below which the drum revolves. The straw with grain is put in at the hopper or feeding board. The revolving drum sucks it in. The spikes or beaters detach the grains and the straw and the grain fall out at the bottom separated. The space between the spikes on the drum and the spikes on the surrounding plate is adjustable, so that the machine can be used for separating large grains as well as small grains. It does excellent work for paddy, *jowar*, *arahar* and Lablab vulgaræ, but it does not do so well with wheat, linseed and gram. Ransome's Bullock-Power Thresher is also in use at the Nagpur Farm. It does better work and much faster than Mayfurth's Hand-Thresher, but it is an expensive machine.

It is very well adapted for threshing wheat, linseed and gram, as well as paddy, *jowar* and *arahar*. This machine is obtainable of Messrs. Ransome Head and Jefferies, Orwell Works, Ipswich, England. Rustom Proctor's Threshing machine costs Rs. 160. It is worked by 12 persons and it is said to execute the work very rapidly. It has been introduced into and mostly used by the members of the Salvation Army at Ahmedabad.

201. *Winnowers.*—Dell's Winnower costs Rs. 265. It cleans the grain from the straw and chaff very rapidly. A winnower is made at the Cawnpore Farm which is sold only for Rs. 60. It is said to work as well as Dell's Winnower. The ordinary fan (*sup* or *kula*) helped by a good breeze is well adapted for the system of cottage husbandry prevalent in India, especially if basketfuls of grain and chaff are gradually let fall from a height. A winnower adapted for separating grain from chaff is sold by Messrs. Burn and Co. for Rs. 65.

CHAPTER XIV.

THEORIES UNDERLYING THE QUESTION OF IRRIGATION.

THE *problem stated.*—Before entering into a description of the various irrigation appliances, it is necessary to deal with certain theories connected with this subject. The question of irrigation is not only the most important, but also the most complicated of all questions connected with Indian agriculture. Experienced cultivators in certain localities are of opinion that well-water is injurious to crops. Where canal-irrigation has been in vogue for a long time, *e.g.*, in parts of the N.-W. P. and the Punjab, cultivators are of opinion that well-

irrigation is to be preferred to canal-irrigation. Again, generally speaking, rain-water has been found to do more good to crops than either canal or well-water, specially at the beginning of rainy season. If well-water or canal-water, or tank-water under certain circumstances, has the property of doing harm to crops, and if rain-water is more generally beneficial, then we must be cautious before venturing on any scheme of irrigation, lest it should afterwards prove to be a thoughtless scheme. A further complication arises from the different effects of irrigation on different crops. At Sibpur Farm, we have observed that the use of the canal water benefits potatoes and cabbages, while it hurts country peas and beans, when owing to late sowing the latter crops had to be irrigated in December and January. Irrigation with this canal water benefits all kinds of crops in May and June, while at the driest season from December to April, this canal water hurts leguminous crops and seedlings of all kinds. What is the explanation of this all? It is only if we understand the theories underlying the question of water adapted for irrigation, that we can avoid mistakes in the use of irrigation water, both as regards quantity and quality.

203. *Rain-water.*—At the beginning of the rainy season rain-water contains in solution and suspension a large amount of foreign substances which are all more or less helpful to agriculture. As the rainy season advances, the water is freer and freer from nitrates, ammonia, organic dust &c. Hence the greater invigorating effect on plant of the early showers of rain. Even in the latter part of the rainy season, 100 cubic inches of rain would contain 2 or 3 cubic inches of atmospheric gases. Every 100 volumes of water are capable of holding in solution under normal conditions of temperature and pressure about 1½ volumes of N; about 3 volumes of O; about 100 volumes of CO_2 and about 7,800, volumes of ammonia. The capacity of rain-water for holding large quantities of CO_2 and ammonia in solution is of special importance for

agriculture. We thus understand how rain-water should benefit the crops in more ways than one, and at the early season more than at a later season.

204. *Well and canal water.*—But why should not spring, well or canal water do more good than rain-water? The former contains more substances in solution than rain-water, not only more CO_2 gas, but also saline substances of various kinds, most of which are actually required for the growth of plants. The danger in using irrigation water lies, not in the fact of the possibility of this water being too poor in soluble substances, but of its being too rich in such substances. Spring or well-water may look purer than river water, but the latter may contain only about one part or less of solids in solution in every 1000 parts, while the former may contain as much as 2 or 3 parts in a hundred. The water of a low and dirty pool may look very clean, but it contains a high proportion of solids in solution. We have said before that plants can take up nourishment only in a very dilute solution, the dilution best adapted for nourishment of plants generally being one part of solid food in solution in 1000 parts of water. 5 parts in 1000 may be taken as the extreme limit of endurance for plants, while 2·5 to 3 parts of solids in solution in 1000 parts of water indicate the danger point, *i.e.*, the degree of solution at which results of the use of water becomes uncertain, specially for leguminous crops and seedlings. The salts in solution may be one or more of the following: Sodium chloride, sodium sulphate, magnesium sulphate, calcium chloride, magnesium chloride, sodium chloride, sodium bicarbonate, calcium carbonate, calcium sulphate, and some silicate, iron, and alumina compounds, also some nitrates and borates. Of these salts, the calcium carbonate, calcium sulphate, silicon, iron and alumina compounds, do no harm when they are present in large proportions in irrigation water, as upon the evaporation of the water after it has been applied on the land, these compounds crystallize out and donot collect

in the soil in a soluble form. The accumulation of the other salts in solution may go on until the proportion of soluble salts in the soil reaches the danger point. Herein lies the danger of irrigating with well water or water from low cesspools or canals which contains a high proportion of undesirable solids in solution. There is another side of the question. Some *soils* contain a high proportion of these undesirable salts in a soluble state, and when to such soils water surcharged with the same salts is applied, the proportion readily reaches the danger point. Soils containing a large excess of these salts are *usar, i.e.,* altogether barren and unfit for cropping, but soils not containing such excess but only a high proportion, may be *rendered usar* by injudicious irrigation. What the proportion of solids in solution in a soil is, and what in the water meant for irrigation, may be determined, and roughly speaking half the quantity in each case may be assumed to be made up of undesirable salts. From these data deduction may be arrived at as to the suitability of the particular, water for the particular soil, remembering always the principle that plants require to be supplied with food at a dilution of about 1 part in 1,000 parts of water.

205. *Evaporation.*—The question of evaporation then comes in, which is further complicated by the fact that evaporation is much slower from land under crop than from bare land, and is different at different seasons, and the whole question of evaporation is of minor importance when one takes into consideration the loss by percolation in certain soils. But leaving all side issues out of consideration, and assuming that a tank 30 ft. deep loses by evaporation 15 ft. of water in course of the year, it would be obviously an advantage to have irrigation from such a deep tank than from one, say, 20 ft. or 18 ft. deep. Just as the 30 ft. tank would lose by evaporation 15 ft., so would the 20 ft. or 18 ft. tank. Now the remaining quantity of the water in the tank would be more or less rich in solids, and the residual 5 ft. or 3 ft. of water

is likely to be too rich in solids unless the water in the tank is rain-water and not water containing an excess of solids in solution to begin with. Here comes the danger of utilising water pumped up from a well or shallow pool of water and stored in a tank for future use for watering plants in the dry season. As evaporation goes on, the residual water becomes more and more concentrated in soluble salts, and the water used for irrigation afterwards may do more harm than good. If storage tanks are made at all for irrigation, and well or pool water stored in such tanks, they must be made as deep as possible, or evaporation should be prevented. But storing of water for agricultural purposes in high level masonry tanks, is not a practicable project, except for such purposes as irrigation of seed-bed &c. But it is in the watering of seedlings specially that the question of the proportion of solids in solution in the water assumes importance.

206. *Quantity.*—The question of quantity of water needed for irrigation is also of great importance. Wherever canal irrigation has been introduced there *raiyats* feel that the more water they use the better value they get for the water rates they pay. This is a very serious error which it is the duty of irrigation officers to dispel. By using too much canal or well water one is bound to suffer sooner or later from the effects of over-irrigation. The complaint is already being heard, that canal irrigation has ruined large tracts of land in the N.-W. P. and Oudh. It is not the fault of the canals, but of over-irrigation, and of utilizing the water at the driest season when it is low down, and when it contains in solution too high a proportion of solids. 1 inch of water once a month, or at most twice a month, should be the maximum allowance in the cold weather, and 2 to 6 inches in the dry weather, according to the period of growth of the plants. From this the quantity obtained by rainfall should be deducted. For rice a larger amount of water is required

at the growing period, *i.e.* about 12 inches per month for a little over 2 months.

207. *Irrigation of paddy fields.*—Suppose one wishes to provide for the irrigation of paddy fields. What provision of water should be made? It is enough if rice plants have ½ an inch of water at their base for 72 days, *i.e.* if they have 36 inches of rainfall during the three months of vigorous growth from July to September. An acre (4840 sqr. yards) would thus require 4840 cub. yds. of water. An allowance of 2,160 cub. yds. may be made for evaporation and percolation, and the total maximum requirements per acre may be thus put down at 7,000 cub. yds. for the 72 days. Now there are 640 acres in a square mile. If a square mile of rice fields has to be provided with the maximum quantity of water (for a season of severe drought), and the water in the canal runs at the rate of 1 mile an hour, a vent of only about 9 sq. feet is required. To provide means of irrigation for any considerable agricultural area by means of tanks and wells is not feasible.

208. *Drainage.*—We have said over-irrigation or irrigation with water surcharged with soluble salts, results in an accumulation of these salts in the soil which gradually render it barren. Where canal irrigation is provided the means of correcting the evils of irrigation should be also provided. This consists in having drainage channels. Drainage would make *usar* land fertile. A land which is drained, readily parts with its soluble salts. Irrigation canals should be built with a fall of 1 foot per mile and the drainage channels should have a fall of 2 feet to the mile, and the drains empty themselves finally into a canal, stream, or river farther down where the level is 6 to 8 feet below the level of the highest portion of the channel where the particular irrigation section begins. Drainage and irrigation channels should be simultaneously provided wherever water other

than rain-water is used for growing crops, whether it is well, or canal or tank water.

209. *Purity of waters.*—What quantity of solids is contained in solution in a particular water intended to be used for irrigation cannot be determined except by an analysis. This analysis for agricultural purposes need not be an elaborate laboratory analysis at all. The readier method of determining soluble salts in a soil is the electrical method, which is applied in practice in field analysis of mineral substances. We will reserve this subject for consideration in the part devoted to Agricultural Chemistry. Of all natural waters rain-water is the purest and safest to use for irrigation. Water of a river flowing through a granite country is also very pure, containing only 2 or 3 grains of solid matter in solution per gallon (*i.e.*, 70,000 grains). The water of a river flowing through a country containing more easily soluble rocks (such as, limestones) often contains 20 to 30 grains of solid matter in solution in every gallon. Spring or well water contains a larger portion of solids in solution, as under pressure at great depth such water absorbs larger volumes of carbon-dioxide, sulphuretted hydrogen and other gases, and it also dissolves saline matters of different kinds from different rocks. Sea water contains as much as 2,400 grains of solids in solution per gallon, of which about 2,000 grains are common salt. Sea water is thus absolutely unfit for purposes of irrigation.

210. *Depth of water, &c.*—For all ordinary purposes the questions of depth of water, volume of water that can be raised per hour, and cost of the appliance used, are of first consideration. This is the subject of water-lifts with which we will deal in the next chapter.

CHAPTER XV.

WATER-LIFTS.

CLASSIFICATION.—By far the most important implement for the Indian *raiyat* is the water-lift. Various forms of water-lifts are in use. The following are adapted for depths of over 25 feet: (1) *Môts,* single and double, (2) Stoney's Water-lift, (3) Persian wheels and (4) Force-pumps and Fire-engines. The following are adapted for medium depths, *i.e.* Depths varying from 10 to 25 feet: (1) Paikota, (2) Tera or Dhenkli, (3) Persian wheels worked by hands and feet, (4) Barrakar and Cawnpore chain pumps, (5) Subha Rao's See-saw water-lift, (6) Deck pumps; (7) Centrifugal pumps; (8) Windmills. The water-lifts adapted for depths smaller than 10 feet are, (1) *Sewnis* or Swing-baskets; (2) Irrigation spoons or ladels; (3) Baldeo balti and (4) Dôn.

212. Of all these water-lifts experimented with, the single *môt* has been pronounced by the authorities in charge of the various Experimental Farms as the best for deep wells, everything being taken into account, and the paikota, the *Dôn* and the *Baldeo Balti*, the best for short lifts.

213. *The single môt* (Fig. 36) with a self-delivery tube which will be understood by a reference to the position of the bucket (which is shown in two positions in the figure) costs only about Rs. 25 setting up, and as it does not require such a wide well as the double *môt* to work it successfully, it is the most suitable water-lifts for fairly well to do cultivators. In the N.-W. P. *môts* are not provided with self-delivery tubes, and there an additional person is needed for emptying the bucket or leather bag when it comes up at the mouth of the well.

The record of an experiment with a single môt conducted in Madras gives the following data: "The *môt* was worked

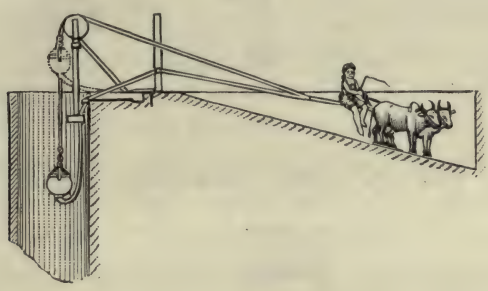


FIG. 36.—THE SINGLE MÒT.

by two bullocks weighing 732 lbs. and 616 lbs. respectively, or in the aggregate 1,348 lbs. The bucket, which was of iron and fitted with a leathern discharging trunk, weighed 43lbs. and when full held 31 gallons of water, but the mean quantity lifted, as measured into a tank, was 24·2 gallons per lift, the rest being spilt or lost by leakage. With the bullocks employed, the rate of working was 90 lifts per hour, and the height of the lift being 23ft, the total quantity of work usefully done amounted to 500.940 ft.-lbs. per hour. The draught exerted by the bullocks down the inclined plane was found to be 383 lbs. The useful work done in a single lift was $24{\cdot}2 \times 10 \times 23$ or 5,570 ft.-lbs. whilst the bullocks exerted a pull of 383lbs. through $25\frac{1}{2}$ ft. the bucket having to be raised an extra $2\frac{1}{2}$ ft. to enable it to discharge its contents, and the work done is equal to 9,760 ft.-lbs. The bullocks then had to return up a gradient of 1 in 5·28 ft. in doing which they expended 6,510 ft.-lbs. of energy in lifting their own weight against the action of gravity. The total amount of work done by them in a single lift was therefore 16,270 ft. lbs. and the useful outturn 5,570 ft.-lbs. so that the efficiency of this method of lifting water is not greater than 33 per cent."

214. *The Double môt.*—The following data occur for an experiment with the Double *môt* conducted in Madras:

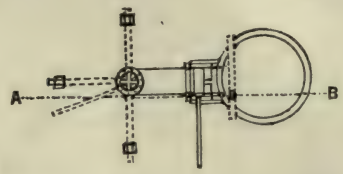


FIG. 37.—THE DOUBLE-MÔT (PLAN).

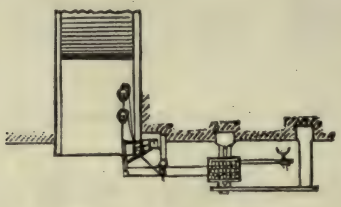


FIG. 38.—THE DOUBLE-MÔT (SECTION THROUGH AB.).

"The buckets were of iron with leathern discharging trunks and were in good order and discharged an average of 28 gallons per bucket as measured into a tank. The trial lasted 3 hours, and in that time 200 buckets of the water raised. The mean lift was 22·125 ft. and the useful work done per hour was 413,000 ft.-lbs. The circumference of the drum of the whim was 12 ft. 11½" and the circumference of the circle in which the bullock walked was 60 ft. 9," so that the velocity ratio was 4·67. The pull on the dynamometer at the ordinary speed of working was 90 lbs. and the pull to just prevent a full bucket descending, 59 lbs. and the pull to just raise a full bucket 81 lbs. The mean between these last two quantities, 70 lbs., is the force at the end of the lever arm required to balance a full bucket of water when friction is eliminated. Multiplying by the mechanical advantage, the unbalanced weight is 327 lbs., a result probably not very much in error as the water in the bucket weighed about 300 lbs. The mechanical efficiency of the lift just moving is therefore 74

per cent. and working at its normal speed, 66·6 per cent. The lifts averaged 1·111 per minute, and the animal was therefore usefully employed for 52·5 per cent. of the time, and the absolute efficiency of the lift as a machine for utilizing the energy of the bullock is $0{\cdot}66 \times 52{\cdot}5$, or 35 per cent."

215. *Stoney's Water-Lift.*—The principal feature in this lift is the employment of buckets of wrought iron suspended in a stirrup by two adjustable pivots attached to the bucket very slightly above the centre of gravity of the bucket when full of water. The mouth of the bucket is inclined and the lower ends of the stirrup are turned outwards and encircle steel wires which are suspended in the well from screwed eye-bolts attached to the framing above. The wires are fastened by some convenient means to the bottom of the well and act as guides to the bucket, ascending and descending, and prevent it from either turning round or swaying to and fro and thus striking either the sides of the well or the second bucket. On the bucket being lowered into the water, it turns horizontal and rapidly fills with water, and on being drawn up assumes a vertical position and rises steadily out of the water till the discharging level is reached, when the upper side of the inclined mouth comes into contact with an iron bar fixed across the framing of the lift, and the stirrup, containing its upward motion, causes the bucket to revolve about the point of contact of the bucket with the iron rod and thus discharge its contents into the delivery trough. The lift, as arranged at Saidapet during the trials, was worked by arranging the ropes which hold the buckets over guide-pulleys to a whim turned by either a pair of bullocks or a single bullock. Two buckets were attached and the ropes arranged so that as one bucket ascended the other descended and the dead weight of the bucket was balanced. The whim consisted of a drum built of wood and carried by an iron spindle on the top of a post firmly built into the ground. The bullocks worked at the end of a long arm, the circum-

ference swept out by which was 3·85 times the circumference of the drum. Thus Stoney's Water-lift is only an adaptation of the Double-môt, where the buckets slide up two wires instead of thumping against the sides, and instead of the self-delivery tubes there is a tilting arrangement.

216. Mr. Subba Rao of the Madras Agricultural Department has introduced an improvement in the Single Môt which consists in balancing the empty môt or bucket by a weight attached over a pulley. It adds considerably to the expense and "it is doubtful if it contributes any real increase to the efficiency of the lift, as the friction of the extra pulley absorbs power and more work is thrown on the drivers since the unbalanced bucket materially assists the driver in climbing the steep ramp," (Bulletin No. 35, Water-lifts, by A. Chatterton, B.SC., 1897.)

217. *The Sultan Water-lift.*—This is a modification of the Double-môt. The buckets are balanced and is each fitted with a valve which opens and allows the water to fill the bucket. When new the valves are water tight but they soon begin to leak. The bullocks walk in a straight and horizontal path and they do not need to be driven backwards. So far the Sultan Water-lift has not been found acceptable, the dead pull being too great for the cattle and the rope. The tilting arrangement is not unlike that of Stoney's Water-lift.

218. *Subba Rao's See-saw Water-lift* (Figs. 39 and 40) also, though a very ingenious contrivance, is not a complete success as yet. "In this form of Water-lift the bullock is made to walk along a platform supported on a roller and by his weight it is caused to oscillate up and down. Two ropes are attached to one end of the platform and wound round to small drums forming part of a species of windlass at the two ends of the large drum round which a rope working an ordinary single-mot is passed. The platform is not supported at the middle, but at some distance therefrom, so that the working end of the platform greatly

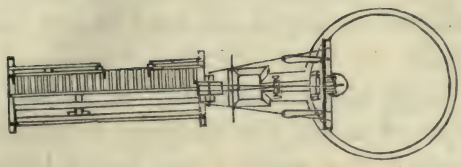


FIG. 39.—SUBBA RAO'S WATER-LIFT (PLAN).

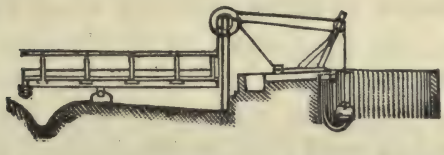


FIG. 40.—SUBBA RAO'S WATER-LIFT (SECTION).

preponderates and the bullock has to walk to the free end of the platform to tilt the longer segment up and lower the bucket into the well. The platform is 24 feet long and the supporting roller is fixed 15 feet $3\frac{3}{4}$ inches from the working end." The weight of the two sections of the platform is 1450 lbs. and 850 lbs. respectively. To diminish the shock when the free end falls and the bucket is lowered into the water, 230lbs. of iron rails are fastened underneath the platform by a short chain, so that just before the end of the platform reaches its lowest position, the rails rest on the ground and their weight ceases to act, and the platform comes to rest more gently than would be the case, if the velocity of descent continued to accelerate to the very end. The ropes from the platform are wound round drums, the circumference of which is 3 feet $2\frac{1}{2}$ inches as measured by unwinding one coil of the rope, and the môt rope is worked from a drum 7 feet 10 inches in circumference, so that the motion of the working end of the platform is multiplied 2·443 times. Mr. Subba Rao told me he intended substituting chains for ropes as ropes lengthen in time and the efficiency

of the lift is reduced in time thereby. With the bucket empty and the platform horizontal, the load at the free end can be varied from 160 lbs. to 362 lbs. without disturbing the equilibrium, whilst with a load of 247 lbs. in the bucket, equal to 24·7 gallons of water, the platform remained horizontal, though the loads at the working end varied between 58 lbs. and 275 lbs. Taking the mean between the two extreme values to be the actual weight required to balance the platform, it is possible by taking moments about the centre, to determine the only force acting on the platform which is not measured, viz., the weight of the empty bucket and ropes acting with a leverage of 2·443 to 1. With the bucket unloaded, the weight works out as 65·4 lbs. and when loaded, 62 lbs.,—a remarkably close agreement. The lift was worked during the trial by a bullock weighing 700lbs. and a man weighing 117lbs. The rate of working was 81 lifts per hour from a well 18 feet 1 inch deep. The average quantity of water brought up by the bucket, as measured into a tank was 23·5 gallons, and the useful work done per hour amounted to 344,210 ft.-lbs. The mechanical efficiency of the lift can be ascertained by multiplying the fall of the front end of the platform by the force required to set it in steady motion when lifting a bucket full of water. The total height the bucket had to rise to discharge its contents was 22 feet and the end of the platform therefore fell 9 feet and the work done was $584 \times 9 = 5,256$ ft.-lbs. To raise the platform back to its initial position, the free end then falls 5·18 feet and the load on it is 362 lbs. and the work done is equal to 1875 ft.-lbs. The total work therefore done in a single lift is 7,131 ft.-lbs. and the useful work given to the water is 4,245 ft.-lbs.; so that the mechanical efficiency when just working is 59·6 per cent; at the normal rate of working it is much lower, probably not more than 50 per cent.

219. Mr. Chatterton thus summarises the trials of the various Madras Water-lifts :—

	Foot-tons of work per lb. weight.
Mr. Stoney's Water-lift	2·253
Double Môt (Saidapet)	1·930
Single Môt (Subba Rao's Improved) ...	2·323
Subba Rao's See-saw Water-lift ...	3·511

He also gives the following figures for comparison of the results of the trials :—

	Stoney's Water-lift.	Double-Môt (Saidapet).	Single-Môt (Subba Rao's Improved).	Subba Rao's See-saw Water-lift.
Useful work in ft.-lbs. per hour (A) ...	571,500	413,000	500,940	344,210
Weight of animals in lb. (B) ...	1,146	1,146	1,348	700
$\frac{A}{B}=C$ ...	498	360	371	492
Mechanical efficiency just moving ...	83·6%	74%	...	59·6%
Mechanical efficiency at working speed ...	79%	66·6%	34·25%	...
Absolute efficiency ...	47·2%	35%	...	...

220. It may be noted here that the orinary *Paicotah* (Fig. 41) though a dangerous instrument is still considered in the Madras Presidency the best appliance for lifting water from small depths (say 10 to 12 ft.) and the single môt the best for lifting water from great depths. The inexpensiveness of the appliances, the ease with which they are set

up and repaired cannot very well be surpassed for very small depths. The swing-basket and the irrigation-spoon (Fig. 1) such as is used in Madras by a single person, are also considered very efficient for small depths.

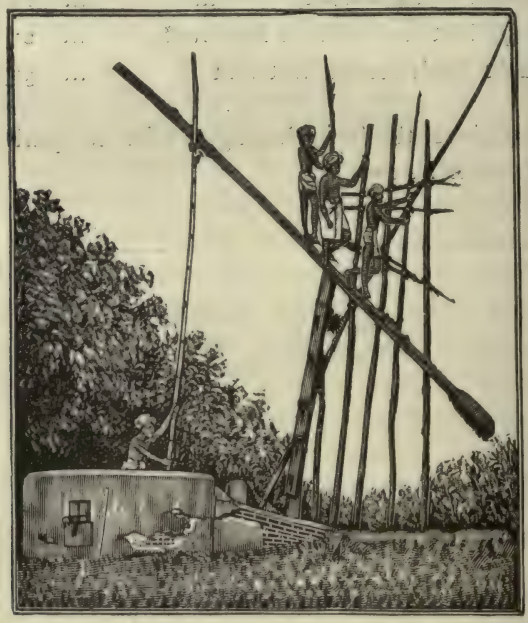


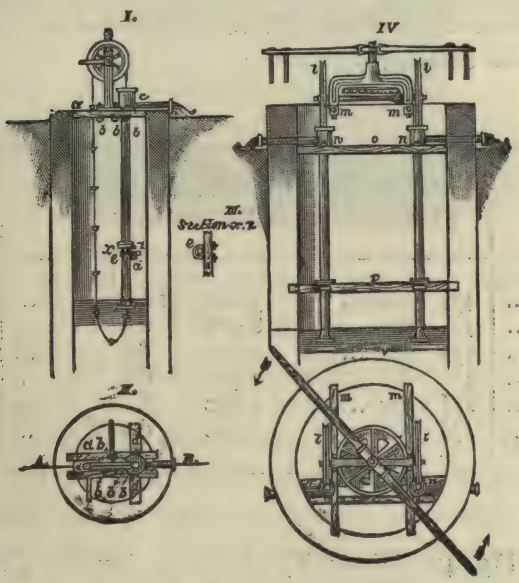
FIG. 41.—PAICOTAH.

221. *Chain-pumps.*—Of the chain-pumps in use, the Barrakar and the Cawnpore Pumps have found favour with the Agricultural Departments of Bengal and the N.-W. P. Between these, the Cawnpore chain-pump, the chain discs of which are fitted with leather washers, works better when new. But the Barrakar pump being of simpler construction, is, on the whole, preferable, and practically there is little difference between the two.

222. These pumps or lifts (Fig. 42) are made entirely of iron. No wood, leather, India-rubber, or anything which might possibly get out of order, owing to climatic influence, is employed on them.

223. *Chain-pump Hand-lift.*—(Fig. 42, I. II and III) work well up to a depth of 25 feet. The cast-iron stand (I),

FIG. 42.—THE BARRAKAR CHAIN-PUMP.



HAND-LIFT. BULLOCK-POWER LIFT.

as well as the top part of the pipe, are fixed on two beams *a a* (I and II), walled into the masonry on the top of the well by means of 6 bolts *b b*. The pipe with top *c* is to be fixed in such a way that the centre of the pipe and the centre of the wheel are in one line *AB* (II). The lower end of the pipe (bell-mouth) should extend at least six inches below the surface of the water. The pipes, for Lifts of more than 10 feet depth of well, ought to be fixed on a beam *d* (I, II, and III) walled into the masonry of the well at a vertical distance of about

2 or 3 feet above the water level by means of an iron strap, *e*, with bolts (I and III) in order to keep them firmly in their proper position. The pipe should not be fixed vertically, but on an incline, according to the slope of the chain (Fig. I), in order to avoid friction as much as possible. The chain-pulley should be worked at the rate of 25 to 40 revolutions per minute, according to depth of well, from 4 to 25 feet, respectively. The following are the approximate capacities of a Chain-pump Hand-lift for different depths of well, if worked by two good coolies :—

Depth of well.	Diameter of pipe.	Approximate quantity of water raised per hour.	Price.
4 feet ...	4½ inches..	15,000 gallons ..	Rs. 35
6 do. ...	4 do. ...	8,000 do. ...	„ 37
10 do. ...	3½ do. ...	4,500 do. ...	„ 40
15 do. ...	3 do. ...	2,500 do. ...	„ 45
20 do. ...	2¾ do. ...	1,800 do. ...	„ 50
25 do. ...	2½ do. ...	1,300 do. ...	„ 55

224. Fig. 42 (IV and V) shows a *Double Chain-pump Lift worked by bullock-power*. It has about three to four times the capacity of a Hand-power Lift, and it can be conveniently worked up to a depth of 40 feet. It consists of a bullock gear, the horizontal shaft of which carries two chain-pulleys, *l l* each working a chain-pump. The gear is fixed with four bolts on two beams, *m m*, walled into the masonry on the top of the well. The top parts of the pipings, *n n*, are fixed with four bolts on two other beams, *o o*, also walled into the masonry of the well. A fifth beam, *p*, serves for fixing the lower part of the pipes similarly as described before for the Hand-lift.

225. *Persian wheels.*—Persian wheels are in use in the Malabar coast and in the Punjab. The former (Fig. 43) are

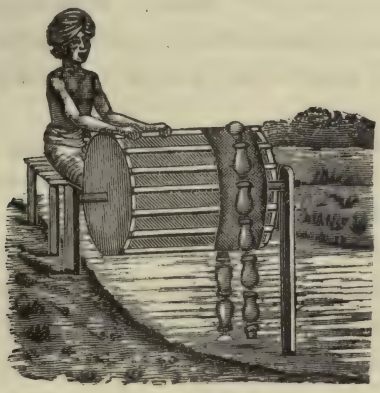


FIG. 43.—PERSIAN WHEEL (RATNAGIRI TYPE).

of very simple and cheap construction. The type illustrated in the figure is used chiefly at Ratnagiri. A bamboo or wooden drum of light frame-work turns on an axle which rests on two pivots. One is at the top of a strong support fixed in water and the other on the top of another support fixed on dry land. A man sits and turns the drum from the land side, while on the water side of the drum hangs a series of mud vessels which are brought up by the revolution of the drum, carrying water in them and discharging the water into a wooden trough from which it flows out to the field. The drum on the water side is padded on the surface with jute or other fibre which offers a soft cushion to the mud vessels.

226. Mr. Andrews, a missionary of Chingleput has built a Persian wheel out of old railway rails, over a circular well 24 ft. 6 inches in diameter. The rotating drum is 6 ft. in diameter and 3 ft. 8 inches wide and carries a double chain of sheet iron buckets, each holding 1·80 gallons. The axle is

prolonged on one side and driven through a pair of bevel wheels by a whim. Each bucket is provided with a leather flap valve to permit of the escape of air from the descending buckets as they enter the water. This improved Persian wheel works very satisfactorily. From a raiyat's point of view, however, it is too costly and it has too many working parts.

227. *Egyptian appliances.*—The Punjab pattern, which is the same as the Egyptian, is also somewhat too complicated for ordinary *raiyats'* use. The Egyptian Persian wheel or Sackiyeh is thus described in Lane's *Modern Egyptians*. "The Sackiyeh mainly consists of a vertical wheel which raises the water in earthen pots attached to cords, and forms a continuous series; a second vertical wheel, fixed to the same axis, with cogs, and a large horizontal cogged wheel, which, being turned by a pair of cows or bulls, or by a single beast, puts in motion the former wheels and pots." Another beautiful Egyptian arrangement for raising water is the Taboot which resembles the Persian wheel in some respects, the chief difference being that pots are not used, but the water is raised up in a large wheel with hollow joints or fellies. The bullock is blind-folded and it goes round and round even without a driver while the cog-wheel to which the shaft of the bullock is attached moves the other two wheels. The wheel with the hollow fellies faces a channel to which seven or eight of the hollows pour out their contents simultaneously while others are coming up in an endless series. This arrangement is adapted only for small depths. The môt (without the self-delivery tube) and the swing-basket are also in use in Egypt, as also the *tera* or shadoof. The shadoof consists of two posts or pillars of wood, or of mud and cane or rushes, about 5 feet in height and less than 3 feet apart, with a horizontal piece of wood extending from top to top to which is suspended a slender lever formed of a branch of a tree, having at one

end a weight, chiefly composed of mud, and at the other, suspended from two long palm sticks, a vessel in the form of a bowl, made of basket work, or of a hoop and piece of woollen stuff or leather. With this vessel the water is thrown up to the height of about 8 feet into a trough hollowed out for its reception. The shadoof is thus a combined tera and swing-basket.

228. The Noria or Bucket-pump is another form of improved Persian wheel, which consists of buckets chained one to another in an endless series and worked by hand or animal power. The following facts and figures taken from the catalogue of Messrs. W. J. & C. T. Burgess (Victoria Works, Brentwood, Essex, England) give a general idea of the efficiency of this kind of water-lift :—

	Gals. pr. hr.	20 feet.	30 feet.	40 feet.	50 feet.	60 feet.	70 feet.	80 feet.
		‡ £ s.	‡ £ s.	‡ £ s.	‡ £ s.	‡ £ s.	‡ £ s.	‡ £ s.
Single chain ...	1,000	1 16 10	1 19 10	1 22 10	Not intended for gtr. depth than 40 ft.			
Double ,, ...	1,000	1 18 3	1 21 9	1 24 15	1 28 1	1 31 8	1 34 15	1 38 1
Single ,, ...	1,500	1 22 0	1 26 10	1 31 0	Not intended for gtr. depth than 40 ft.			
Double ,, ...	1,500	1 22 0	1 26 10	1 31 0	1 35 10	1 40 0	2 45 12	2 50 2

‡ Number of bullocks or donkeys needed.

229. Wind-mills and aeromotors have been already described in Chapter XI. Full directions for erecting these are given in the catalogues of the Companies constructing and supplying them (Vide Part 1 of Catalogue No. 29 of Freeman Steel Wind Mills, S. Freeman and Sons, Manufacturing Co., Racine, Wis. U. S. A.

230. *The Baldeo Balti.*—An ingenious mechanical adaptation of the *dôn* (or canoe-shaped water-lift) for watering from small depths, known as the Baldeo Balti, is the invention of Baldeo, the agricultural-mechanic of the N.-W. P. Agricultural Department. It is a double *dôn* worked by a single bullock. The bullock goes round and round a tree or post to which the yoke-pole is attached. When one of the *dôns* rises and

discharges its water, the other goes down, the entrance of water into the empty *dôn* being facilitated by means of a



FIG. 44.—THE BALDEO BALTI.

valve. The arrangement of the strings to which the two *dôns* are tied after passing over three pulleys, can be best understood from the above diagram (Fig. 44.)

231. *Artesian Wells.*—The question of sinking artesian



FIG. 45.—NUBIAN TUBE-WELL.

wells and tube-wells (Fig. 45) both for irrigation and drinking

purposes is a very important one, but its solution cannot be said to have been accomplished as yet in this country. Dr. Dyson, Sanitary Commissioner for Bengal drew special attention to this subject in a note, dated the 31st March 1896. In concluding this note, Dr. Dyson remarks.—"The Saidpore investigation confirms my favourable impression of tube wells as an easy means of obtaining pure and wholesome water. I am not, however, prepared to recommend their universal use, because they are not suitable for all soils, but wherever they can be got to work, I think they ought to be used in preference to ordinary wells and tanks, than which they are much cheaper and far more satisfactory. They are specially suited for a loose sandy soil like that of Saidpore. In hard laterite soil, or in clay, they cannot, of course, be got to work, and in alluvial soil, like that of Chittagong, Noakhali, Backergunge &c., it is not desirable that they should be tried, as in these places, which are subject to the influence of sea-waves and salt tides, the water is brackish. It might be mentioned that in soil which is suitable, the sandy beds of *nalas* and the dry beds of good tanks, offer the best prospects of rapidly sinking a water supply which is practically inexhaustible."

232. Of the firms which manufacture and supply Artesian and Tube-Wells and the driving apparatus and boring tools, may be mentioned Messrs. C. Isler & Co., Artesian Works, Bear Lane, Southwark, London, S. E., Messrs. W. Leslie & Co. of Calcutta supply Tube-Wells at the following prices:—

Drive point and 20 ft. 1½ inch wrought iron tube in short lengths with a *pitcher pump*	...	...	...	Rs. 45
25 ft.	...	...	...	„ 50
30 „	...	...	...	„ 55
40 „	...	...	...	„ 60



FIG. 46.—MANNER OF FIXING NUBIAN TUBE-WELLS.



FIG. 47.—THE DRIVE-POINT AND MONKEY GEAR.

The price of the driving apparatus, the same set serving for any number, is Rs. 45. The manner of planting the drive-point first, is illustrated in Fig. 47, and the whole arrangement for fixing the well in Fig. 46.

233. Another device for irrigation called the Windlass

and Bucket Lift is illustrated in Fig. 48. It is useful for bringing water from a stream or canal to adjoining fields. The two positions of the same bucket are illustrated in the figure.

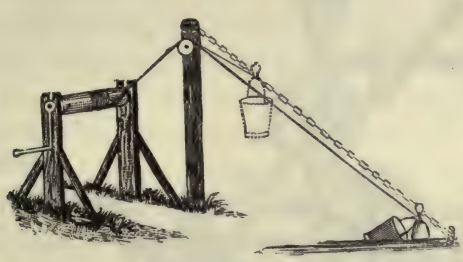


FIG. 48.—WINDLASS AND BUCKET LIFT.

234. *Fire-engines and other pumps.*—Of Suction and Force Pumps suitable for irrigation, the first place must be given to Fire-engines. Heathman's Platform Fire-Engine and Hand Curricle Fire-Engine are excellent for pumping sewage, irrigating, as well as for putting out fires. Village unions or *tehsildars* should have these for letting out on emergencies and also for regular irrigation purposes, at so much per day. The suction can take place from a depth of 28 ft. and as much as 600 ft. of delivery hose can be forced through. Heathman's Platform Fire-Engine No. 1 worked by 2 to 4 persons and discharging about 2,000 gallons of water per hour over a height of 60 ft. is priced £12—10—6. Heathman's* Truck-Force-Pump which can be moved about from place to place, and worked by one man, pumps up about 500 gallons of water or liquid manure, per hour. This pump is also used as a fire-engine. Its price with 10 feet of Suction-hose and 2 feet of Discharge-hose and spray fan and nozzle complete, is 110 shillings for a 3-inch pump and 100 shillings for a 2½-inch pump.

* J. H. Heathman & Co., Manufacturers, 2 & 37, Endell Street, London, W. C.

235. Of suction and force pumps may be also recommended the "Handy" or Semi-rotary Wing Pump mounted on wheels (Fig. 49). These are priced by Messrs. W. Leslie

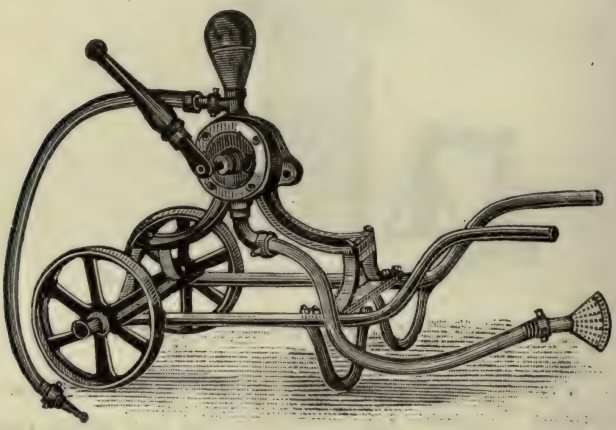


FIG. 49.—SEMI-ROTARY WING PUMP.

& Co. of Calcutta at Rs. 125. They raise 300 to 500 gallons of water per hour.

236. Handier Syringe pumps are specially adapted for applying insecticides and fungicides. Of these may be recommended Messrs. Heathman's Brigade Suction Pump, made of brass and copper. It ejects to a distance of about 30 feet 300 gallons of liquid per hour. With 6 ft. suction-hose and strainer, 2 ft. delivery-hose and nozzle, the price is 50 shillings. Extra suction-hose costs ½d. per foot and extra delivery-hose 8½d. per foot.

237. *Centrifugal pumps* which do not possess valves and washers are not so liable to get out of order as ordinary suction and force pumps, and if such are made with multiplying wheels suitable for hand driving, they may prove a boon to our raiyats. Centrifugal pumps are in common use in indigo plantations and in factories in this country, but these are worked with steam-power.

238. *Comparison of costs &c.*—The centrifugal pump used for irrigation purpose at the Cawnpore Experimental Farm irrigates 4 acres of land per day and it costs Rs. 5 per day in coal, oil and wages of the mechanic. The Cawnpore chain pump worked by 2 men (4 men being required for working it without interruption) irrigates about an acre a day at a cost of about 8 annas where the water is within 4 feet as at Cawnpore. Where the water is deeper, say 10 to 12 feet, as at Sibpur, the Barakar pump (which is something like the Cawnpore pump) is able to irrigate only $\frac{1}{3}$rd of an acre a day, *i.e.* less than the swing-basket does and the wages of labour also are at Sibpur double of what they are at Cawnpore, so that the cost per acre is about Rs. 3 at Sibpur against 8 annas the cost incurred at Cawnpore. The Baldeo Water-lift irrigates about $\frac{1}{3}$rd of an acre per day at a cost of 6 as. (one bullock and one man), under conditions prvailing at Cawnpore. The Stoney's Water-Lift worked by a strong pair of bullocks and a man, irrigates from a deep well of 30 to 40 ft. about $\frac{1}{3}$rd of an acre per diem at a cost of 12 as. (about Re. 1/8 in Calcutta). On sandy soils less work can be done and on stiff clay soils more. The figures given apply to a medium loam. It is important to compare these high class or improved irrigation appliances with those in common use in this country, *viz.*, the swing-basket, the *tera*, the *dôn*, the single and double *môt* and the single Persian wheel (Punjab pattern). (1) To work the swing-basket three men are required, the man distributing the water relieving in turn the two men employed in baling out the water. The height to which the water can be lifted with the swing-basket is 5 up to 10 feet. About $\frac{1}{3}$rd cub. ft. of water is thrown up each time and there are about 20 deliveries per minute, which gives 400 cub. ft. of water per hour. If 25 per cent. is allowed for wastage, percolation &c., the actual discharge comes to 300 cub. ft. *i. e.*, 1890 gallons. (2) To work the *tera* or *dhekli* (*i.e.*, the ordinary lever and

bucket-lift) one man is employed at the bucket and one man for distributing the water. The water can be easily raised 16 ft. high. The contents of the bucket or *dôl* is ½ cub. ft. The number of discharges per minute is about 3. The discharge per hour is therefore 90 cub. ft. Allowing 10 per cent. in this case for wastage, we get about 81 cub. ft. — 500 gallons per hour. (3) The *Dôn* or Canoe-shaped lift made of trunks of trees hollowed out or of iron (iron *dôns* being now in common use in Birbhum and Murshidabad), is also worked by one man. It raises water only up to a height of 5 or 6 ft. There are 10 deliveries per minute each delivery being about 3 cub. ft.; 1800 cub. ft. are thus lifted per hour. Waste of only about 10 per cent. takes place in this case also. The actual quantity of water lifted is therefore 1620 cub. ft. which at $6\frac{3}{10}$ gallons per cub. ft. gives 10,206 gallons per hour. (4) To work the single-*môt* with self-delivery tube, one man and two bullocks are required besides the man distributing the water. Water can be lifted from a depth of 40 to 80 ft. The bullocks walk at the rate of 2 miles an hour. For each lift of 40 ft. the bullocks traverse 80 ft. The contents of the bag or bucket is 3 cub. ft. The number of lifts per minute is only one. So the discharge per hour is 60×3 *i. e.* 180 cub. ft. Allowing 25 per cent. of loss by spilling 135 cub. ft. or 850 gallons per hour is the result obtained. But whereas, at the Sibpur farm, spilling is avoided by the bucket being made to slide up two tight steel ropes as in Stoney's Water-Lift, the loss may be put down at only 10 per cent. and in that case we get over 1000 gallons per hour. The draught or traction required being 255 lbs., two bullocks are essential. (5) The *Double-môt* also requires one man and two bullocks. The diameter of the whim being 3ft. and the diameter of the bullock-walk being 16ft., the bullocks walking at the rate of 2 miles per hour can take 3·4 turns per minute. The time taken for raising the bag or bucket from a depth of 40ft. is 1·4 minutes. The content of the bag or bucket being 3 cub.ft.,

the discharge per hour from the two bags or buckets comes to 252 cub. ft. of which 35 per cent. may be calculated for wastage. Thus we arrive at 165 cub. ft. or 1045 gallons per hour. The ratio of power to weight where the diameter of whim and bullock-walk are 3ft. and 16ft. is 3 : 16. The total weight raised each time being 460 lbs., the draught exerted is 124 lbs., or considerably less than in the case of the single-*môt*. (6) To work the single Persian wheel also 1 man and 2 bullocks (or even 1 bullock) besides the man distributing water, are required. The water being raised 40 ft., the diameter of the driving wheel being 4 ft., the diameter of the wheel to which the buckets or pots are attached being also 4 ft., assuming the content of each bucket $\frac{1}{8}$ cub.-ft. and 6 buckets being emptied at each turn of the bullocks, the discharge at each turn comes to $\frac{3}{4}$ cub.-ft. The length of the bullock-walk being 62·8ft. and the speed of bullocks being 2 miles an hour, the bullocks make 2·8 turns per minute. The discharge per hour is therefore 126 cub. ft. of which 45 per cent. may be allowed for wastage. The actual discharge thus comes to 69·3 cub.-ft. or 429 gallons per hour. The buckets being tied 2ft. apart from middle to middle, the number of buckets in one endless chain is 40. The weight of buckets is about 80lbs. 20 buckets being always full the weight of water they contain is 156lbs. The weight of the rope is 22lbs. The total weight raised is therefore 258lbs. The modulus being ·6, the power required to raise 258lbs. is 430lbs. The ratio between this power and the power exerted by bullocks being about 1:5, the draught or power exerted is only 86lbs., which is lighter still than in the case of the Double-*môt*. Such a Persian wheel can be worked by 1 bullock only.

239. From the above figures it may be seen that the native irrigation appliances are by no means to be despised, and that taking all things into consideration we come to the following conclusions:—(1) the *Dôn* is the best implement

for Indian use for small depths (up to 6ft.), its lifting capacity, being 10,000 gallons per hour. (2) Next to it comes the swing-basket which in the hands of dexterous coolies will lift about 2,000 gallons of water per hour from a depth of 10 ft. (3) For medium depths, either a double or triple series of *dôns*, or the lever and bucket-lift (*tera*) is the best. 500 gallons of water can be raised per hour with *tera*. (4) For great depths, the Single and Double *môt* and the Egyptian or Punjab pattern Persian wheel are the best. The *môts* will give about 1,000 gallons per hour, and the Persian wheel about 500 gallons. Considering the cost, the Single *môt* is to be preferred to all others for great depths, and to adapt ordinary ring wells of only 3 ft. diameter, and to avoid spilling of water, the bucket can be made to slide up two steel ropes stretched vertically from the bottom of the well up to the beam whence the pulley is suspended. To irrigate an acre of land, 50,000 gallons are required for clay-soils, and 100,000 gallons for sandy loams. The latter quantity is equivalent to about ½ an inch of rain-fall, which is enough to soak thoroughly 6 inches of soil. For more thorough irrigation, double the above quantities may be allowed, *viz.*, 100,000 gallons per acre for clay-soils and 200,000 gallons per acre for sandy loams, and the arrangements needed for irrigating a particular locality with any of the water-lifts or pumps described above, can be worked out for every particular locality.

CHAPTER XVI.

OTHER AGRICULTURAL IMPLEMENTS.

OF other implements and machinery that are or may be used in agricultural operations may be mentioned the following:—

(1) *Bulls' Dredger* for sinking wells. These are made

in the workshop of the Cawnpore Experimental Farm and sold for Rs. 180 to Rs. 210.

(2) *Rice-huskers* or hullers and polishers which will be dealt with separately in the next Part in connection with the rice crop.

(3) *Chaff-cutter* (Fig. 50), by Messrs. Burn & Co., price Rs. 53.

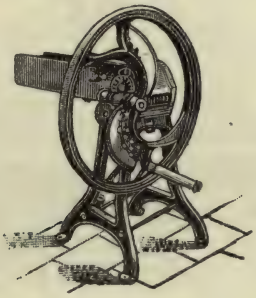


FIG. 50.—CHAFF-CUTTER.

(4) *Root-cutter.*—Ordinary *dáo* or *kátári* does the work more slowly.

(5) *Root Pulper.*—*Dhenki* with cemented mortar answers fairly well.

(6) *Kibbler* or a mill for crushing grain, oats, maize, barley and other corn. One crushing 3 bushels of corn per hour is sold at the Cawnpore Experimental Farm for Rs. 35.

(7) *Oil-cake crusher*, by Messrs. Oakes & Co. of Madras, price Rs. 57.

(8) Steel *hand-mill for grinding wheat* for whole-meal (*átá*), also barley, oats, maize, &c., by Messrs. Burn & Co. The Flour Dressing Machine No. 5 is said to grind and dress 30 to 45 seers per hour, and it is priced Rs. 210.

(9) Hand-power *hay-trusser.*

(10) *Ghâni, Kolu* or *oil-mill.*

(11) *Feeding troughs* and *hurdles.*

(12) *Bone-mill* and stone-grinder.

(13) *Maize-huller* (Fig. 51).

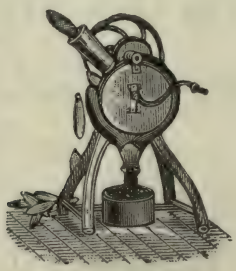


FIG. 51.—MAIZE-HULLER.

(14) *Cotton-gin.*—The Macarthy Hand-Cotton-gin (price Rs. 220), obtainable of Messrs. N. D. Maxwell & Co. of Bombay. It cleans 140 lbs. of cotton in seed per diem, about $\frac{1}{3}$rd lint and two thirds seed (according to the variety of cotton ginned) being obtained. The seed is not injured and it remains fit for sowing.

(15) *Sugarcane mill, &c.*, to be described in Part III in connection with the sugarcane crop.

(16) *Silos* to be described in Part V in connection with Fodder crops.

(17) *Dairy implements,* to be described in Part V in connection with milch-cows.

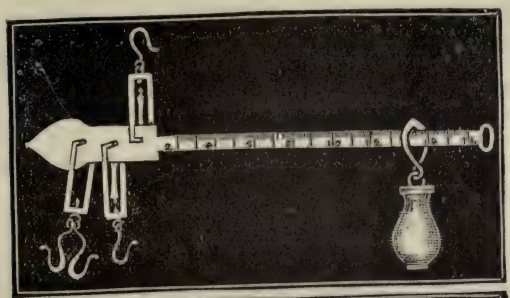
(18) *Appliances for spraying or dusting insecticides and fungicides,* to be described in connection with Insect and Fungus Pests.

(19) *Carts.*

(20) *Balances.*—Platform weighing machines though highly useful for experimental farms where weighing of cattle or of cart-loads of crops, straw, manure, &c. has to be done, are too expensive for ordinary agricultural use. The common scale-beam with wooden pans and iron weights, obtainable in bazaars, is the best for such use. As weights are liable to get lost if they are too frequently used, for daily

weighings of small quantities up to 50 lbs., the balance best adopted is the steel-yard.

FIG. 52.—STEEL-YARD FOR WEIGHING UP TO 16 lbs.



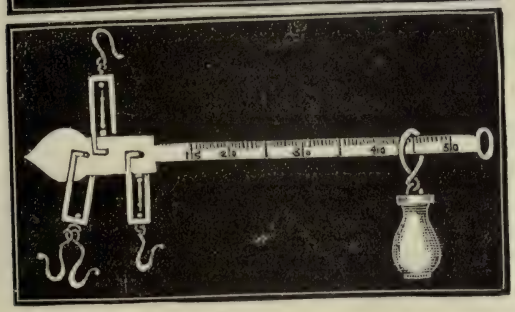


FIG. 53.—STEEL-YARD FOR WEIGHING 15 TO 50 lbs. (FIG. 52 REVERSED).

Fig. 52 represents the position of the steel-yard in which weights from 2 to 16 lbs. can be determined, as the figures marked on the iron-bar will show. It should be hung on something high by the hook nearest to the arm. The middle hook will not be used at all in this case. The article to be weighed is to be hung on the double-hooks. This being done, move the weight on the arm or bar till it assumes a perfectly horizontal position. The figure on which the weight will rest will indicate the weight in pounds of the article weighed. Figure 53 represents the position of the same instrument reversed, in which weights from 15 to 50 lbs. can be determined as is shown by the figures on the

iron-bar or arm. In this case the steel-yard is suspended by the middle hookand the hook nearest the arm is not used at all. This steel-yard supplied by the Agricultural Department and used at the Sibpur Farm, has been found a very handy instrument.

(21) Machinery for tea, indigo, coffee and other planting enterprises in which European capital and intellect are employed are not necessary to be described in a Hand-book of agriculture, though these subjects will receive some attention in their proper places in Part III.

CHAPTER XVII.

EQUIPMENT OF FARMS.

PRINCIPLES stated.—Having described the principal agricultural machinery that are or may be employed with advantage in this country, it now remains for us to find out some principle of equipment that may be applied in every case *mutatis mutandis*. We have said that heavy soils require a larger number of cattle and men, and consequently a larger number of some of the cultivating appliances, than light soils. There is another consideration that will materially affect the question of equipment, *viz.*, the system of farming adopted. One labourer for 2 acres and one yoke of oxen for every 5 acres of heavy land, is the allowance for ordinary arable or mixed farming. Where gardening instead of farming is the system mainly employed, *e.g.* in market-gardening near large towns, where the largest outturn from the smallest area by high farming is the aim, the allotment for cattle and farm implements should be insignificant and the allotments for hand-labour, garden-tools (spade, hoe, rake, scissors, *dáo* &c.), and manure should be higher. In ordinary arable farming, no separate

allotment for manure is needed. The aim should be to feed the bullocks well with oil-cake and the natural manure of cattle, fallowing, growing of leguminous crops and returning to the land the straw in the form of litter mixed with urine, should be the main stay. But in growing special crops such as tobacco, mulberry, sugarcane, potatoes, manuring is essential. The equipment needed in each case thus depends on the land chosen, the crops chosen, and the system of farming adopted. In dairy farming again no allotment is necessary for manure, and proportionately less allotment is needed for bullocks, farm labourers, ordinary agricultural implements, but for stocking the land with suitable cows, for providing fodder at all seasons, for equipping a proper dairy, special allotments are needed. Then again the allotment for buildings and implements should be proportionately higher for a small farm than for a large farm. If Rs. 10 per acre is set apart for buildings, Rs. 10 per acre for implements and Rs. 10 per acre for cattle for a 500-acre farm, and Rs. 50 per acre per annum for working the farm, though Rs. 10 per acre for cattle and Rs. 50 per acre per annum for expenses, will answer for a 10-acre farm, Rs. 10 per acre for buildings and Rs. 10 per acre for implements will not suffice for a 10-acre farm. Local circumstances also determine cost. In healthy localities cheap buildings answer. In places close to town there are certain special facilities and disadvantages.

242. In an experimental farm again, where the fodder, the dung, the urine etc., have to be weighed ; where small lots of corn have to be separately thrashed, dried, weighed and stored, where detailed accounts of experiments have to be recorded, more money must be spent on the supervising staff and labour force, if the experiments are to give really reliable results.

243. As the circumstances may thus vary almost infinitely, as we will separately estimate the cost of growing each

of the principal crops, our aim for the present will be to give a typical example, draw certain definite conclusions from it, and recommend the application of these deduced principles in each particular case, *mutatis mutandis*. In fact we have already hinted what we are going to do, *i.e.*, infer from a typical case of a 400-acre farm, that about Rs. 10 per acre should be allotted for buildings, Rs. 10 per acre for cattle, Rs. 10 per acre for implements, by way of capital charge, and Rs. 50 per acre by way of annual expenditure. If, however, the farm is very much smaller, an increased proportion for buildings and implements, and if the farm is very much larger, a diminished proportion for buildings and implements, will be needed. The principle enunciated here refers only to mixed farms, and not to gardens or plantations.

244. *Capital charge.*—The principal implements &c., required for a farm of 400 acres of heavy arable land like that of the Sibpur Farm are :—

160 Bullocks @ Rs. 25/	Rs. 4,000
	i. e., Rs. 10 per acre for cattle.
16 Carts	Rs. 240
1 Water-Cart	„ 100
1 Spring-Cart for market	„ 200
1 Pony with harness for market	„ 100
1 Gun for killing jackals &c.	„ 100
80 Sibpur ploughs	„ 640
2 Ridging ploughs	„ 100
4 Five-tined grubbers	„ 80
4 Zig-zag harrows	„ 160
4 Bakhars	„ 20
4 Wooden rollers	„ 80
8 Ladders	„ 4
4 Beam-harrows	„ 20
1 American Seed-drill	„ 50
4 Wide bullock-hoes (*Dundias*)	„ 32
4 Narrow bullock-hoes	„ 20

8 Planet Jr. Hand-hoes	„	160
2 Chaff-cutters	„	80
1 Corn-crusher	„	40
1 Cake-crusher	„	100
1 Turnip pulper	„	100
40 *dôns*	„	400
Other suitable irrigation appliances, *môt* &c.,		500
20 Dozen hurdles	„	250
Scales and weights for weighing up to 2mds.	„	20
1 Steel-yard	„	4
1 Small pair of scales (& weights) ...	„	2
1 Grindstone, 24″ diameter	„	20
4 Scythes	„	40
20 Hooks or sickles	„	8
1 Hand-thresher	„	200
1 Winnower	„	65
Chains, rope, bamboos &c.	„	115
		Rs. 4,000

i. e. Rs. 10 per acre for implements.

Sheds for 100 resident labourers ...	Rs.	2,000
Covered shed for manure pits ...	„	200
Shed for bullocks	„	300
Barn and Godown	„	1,000
House for residence of Farm Overseer	„	500
		Rs. 4,000

i. e. Rs. 10 per acre for sheds and godowns.

245. The *annual expense* of working the above farm can be estimated thus :—

200 labourers at Rs. 6 per month ...	Rs.	14,400
Overseer or bailiff on Rs. 50 ...	„	600

Oil-cake @ 1 maund per bullock per month, @ Re. 1/8 per maund ...	,,	3,000
Rent	,,	1,200
Other expenses	,,	800
	Rs.	20,000
	i. e. Rs.	50 per acre.

246. By ordinary farming, *i. e.*, by cultivating rice and pulses, with hired labour, a capitalist cannot expect to make farming pay in this country. One gets about 15 maunds of paddy and 10 maunds of pulses per acre, which sold at Rs. 2 a maund yields only Rs. 50 per acre. By judicious cropping two crops can be taken every year out of the land, or one crop of double value, such as sugarcane, tobacco &c., or a crop which costs much less in cultivating, as jute, pulses &c. But the average outturn per acre from mixed farming may be safely put down at Rs. 50 and the cost also at Rs. 50. Ordinary farming therefore just keeps the cultivators who are their own field labourers, and it pays them no better than service as coolie.

247. It is only by growing special crops, such as sugarcane &c., that a capitalist or a gentleman-farmer may hope to make farming pay. But it is never safe to rely on one crop only and it is best to choose 4 or 5 paying crops, and grow these in rotation, though the cost of growing such crops is greater. An acre of sugarcane will cost about Rs. 150 growing, but the *gur* from it is worth Rs. 200. What each crop costs and what outturn we may expect from it, is a question which we will discuss in the next Part of the Hand book.

PART III.

CROPS.

CHAPTER XVIII.

BOTANICAL CLASSIFICATION OF CROPS.

THE principal agricultural crops &c., may be thus exhibited under the various natural orders to which they belong:—

Monocotytedons.

(1) *Gramineæ*—

1. Paddy (oryza sativa) C.
2. Wheat (Triticum Sativum) C.
3. Barley (Hordeum hexastichum) C.
4. Oats (Avena sativa) C & F.
5. Deodhán or Juár (Andropogon sorghum) C & F.
6. Cheena (Panicum miliaceum) C & F.
7. Kayon (Panicum Italicum) C.
8. Maize (Zea mays) C.
9. Shámá or Bhura (Panicum frumentaceum) C & F.
10. Gondli (Panicum miliare) C.
11. Menjhri (Panicum psilopodeum) C.
12. Maruá (Eleusine coracana) C.
13. Kodo (Paspalum scrobiculatum) C.
14. Bájrá (Pennisetum typhoideum) C.
15. Ulu or thatching grass (Imperata arundinacea) M.
16. Káshá, *khág* or reed (Saccharum spontaneum) M.
17. Sugarcane (saccharum officinarum) M.
18. Munj (Saccharum ciliare) FB.
19. Durba (Cynodon dactylon) F.
20. Bamboo (Bambusa arundinacea) M.
21. Latá-grass or para-grass (Panicum muticum) F.
22. Erá-kati (Ischæmum rugosum.)

(II). *Cyperaceæ.*—

1. Mádur Káthi (cyperus tagetum) M.
2. Chufa (Scirpus Kysoor) M.
3. Muthá grass (Cyperus rotundus) F.

(III). *Amaryllidaceæ.*—Agaves FB.

(IV). *Liliaceæ.*—

1. Onions (Allium ascalonicum) V.
2. Garlic (Allium Sativum) V.
3. Asparagus (A. officinalis) V.
4. Yucca gigantia, aloifolia &c. FB.
5. Dracæna ovalifolia. F.
6. Sansivieras FB.

(V) *Aroideæ.*—

1. Mán Kachu (Alocasia Indica) R.
2. Kachu (Colocasia Antiquorum) R & V.
3. Ol (Arum Campanulatum) R.

(VI) *Bromeliaceæ.*—Pineapple (Ananas sativa) FT & FB.

(VII). *Dioscoreæ.*—

1. Khám álu or Gách álu (Dioscorea sativa) R.
2. Chupri álu (D. Globoso) R.
3. Lál garániyá álu (D. propurea) R.
4. Sutni-álu (D. fasciculatá) R.

(VIII). *Musaceæ.*—Plantains (Musa Sapientum) FT & V.
Manilla hemp (Musa textiles) FB.

(IX) *Zinziberaceæ.*—

1. Ginger (Zingiber officinale) S.
2. Turmeric (Curcuma longa) S.
3. Amada (C. amada) S.
4. Sathi or zedoary (Curcuma Zedoaria) R.

(X). *Cannaceæ.*—

1. Arrowroot (Maranta Arundinacea) R.
2. Canna Edulis R.

Dicotyledons.

(XI). *Piperaceæ.*—

1. Betel (Peper betel) S.
2. Peepul (Piper longum) S.

3. Chai (Piper chaba) S.
4. Round pepper (Piper nigrum) S.

(XII). *Euphorbiaceæ.*—

1. Castor (Ricinus communis) O.
2. Cassava (Manihot utilissima and aipi) R.
3. Papaya (Carica Papaya) FT. & V.

(XIII.) *Moreæ* (*Mulberry*).—

1. M. Alba F.
2. M. Serrata F & T.
3. M. Nigra FT.

(XIV). *Sesameæ.*—Sesamum, gingelly or *til* (sesamum Indicum) O.

(XV). *Solanæ.*—

1. Potatoes (Salanum tuberosum) R.
2. Brinjals (Solanum Melongena) V.
3. Kulibegun and bárometshe begun (S. longum) V.
4. Chillies (Capsicum frutescens) S.
5. Tempari or Cape Goose-berry (Physalis Peruviana) FT.
6. Tomato (Loycopersicum esculentum) V.
7. Tree-tomato or Java plum (Cyphomandra betacea) FT.
8. Tobacco (Necotina rustica & N. Tabacum) D.

(XVI.) *Couvolvalaceæ.*—Rángá álu, sádá álu (Batatus edules) R.

(XVII). *Cucurbitaceæ.*—

1. Láu (Lagenaria vulgaris) V.
2. Kumrá, biliti and deshi (cucurbita maxima and pepo) V.
3. Uchhe (Momordica muricata) V.
4. Jhinga (Luffa acutangula) V.
5. Dhundul (Luffa Ægyptiaca) V.
6. Tarmuj (citrulus vulgaris) FT.
7. Khero (round cucumber) and
8. Shashá (ordinary cucumber) (Cucumis sativus) V. and FT.
9. Phuti (Cucumis momordica) FT.
10. Gomukh (Cucumis maderaspatnus) V.
11. Kánkri or bákhári (Cucumis utilissimus) V.

12. Kánkrol (Momordica Cochinchinensis) V.
13. Karala (Momordica charantia) V.
14. Chichinga (Trichasanthes anguina) V.
15. Patal (Trichosanthes dioica) V.
16. Kundruki (Trichosanthes diseca) V & FT.

(XVIII). *Leguminosæ.*—

1. Peas (Pisum arvense) P.
2. Payra Matar (Pisum quadratus) P.
3. Kalái (Phaseolus radiatus) P.
4. Mug (P. Mungo) P.
5. Gram (Cicer arietenum) P.
6. Mushuri (Ervum lens) P.
7. Kheshári (Lathyrus sativus) P.
8. Arahar (Cajanus Indicus P.
9. Rambha or Barbati (Vigna catiang) P & V.
10. Sunn hemp (Crotolaria juncea) FB.
11. Indigo (Indigofera tinctoria)DE.
12. Dhainchá (Sesbania aculeata) FB.
13. Sajná (Moringa pterygosperma) V.
14. Bhiringi (Phaseolus aconitifolius) P & F.
15. Kurthi (Dolichos biflorus) P & F.
16. Arhariá Sim (Cyamopsis Psoroiloides) F & V.
17. Groundnut (Arachis hipogia) O.
18. Babul (Acacia arabica) F & T & De,
19. Palas (Butea frondosa) M.
20. Baklá (Vicia faba) P.
21. Sim (Dolichos lablab) P & V.
22. Mákhan Sim (Canavalia gladiata) V.
23. Sola (Aeschynomena aspera) M.
24. Tamarind (Tamarindas Indica) S.

(XIX). *Lineæ.*—Linseed (Linum Usita tissimum) O.

(XX). *Tiliaceæ.*—

1. Sirajgunj Jute (Corchorus capsularis) FB.
2. Deshi Jute (C. Olitorius) FB.

(XXI). *Malvaceæ.*—

1. Cotton or Kápás (Gossypeum herbaceum *etc.*) FB.
2. Silk-Cotton or Simul (Bombax malabaricum) FB.

3. Musk mallow (Hibiscus abelmoschus) FB. and D.
4. Ambori hemp or mestápát (H. cannabinus) FB.
5. Roselle or mesta (H. sabdariffa) V.
6. Ladies' finger (H. esculentus) V.

(XXII). *Cruciferæ*.—

1. Mustard (Brassica campestris and juncea) O.
2. Cabbages, Cauliflower and Kohlrabi. (Brassica oleracia) V.
3. Turnips (Brassica napa) V.
4. Radishes (Raphanus sativus) V.

(XXIII). *Compositæ*—

1. Sunflower (Helianthus annuus) O.
2. Artichoke (Cynara scolymus) V.
3. Jerusalem artichoke (Helianthus tuberosus) V.
4. Safflower (Carthamus tinctorius) O. & De.
5. Lettuce (Lactuca sativa) V.
6. Sorguja (Guizotia Abyssinica) O.

(XXIV). *Polygonaceæ*.—Buckwheat (Fagopyrum esculentum) C.

(XXV). *Chenopodiaceæ*.—

1. Beet and mangold (Beta vulgaris and cycla) V. & F.
2. Pálam (Beta Bengalensis) P.H.
3. Chukapálam (Rumex vesicarris) P. H.

(XXVI). *Umbelliferæ*.—

1. Carrot (Daucus carota) V.
2. Celery (Apium graveolens) V. & S.
3. Coriander (Coriandum sativum) S.
4. Anise (Pimpinella anisum) S.

(XXVII). *Urticaceæ*.—

1. Ban Riha (Vilebrunia integrifolia) FB.
2. Rhea (Bœhmeria Nivea) FB.

(XXVIII). *Onagraceæ*.—Water-nut or *Singhárá* (Trapa bispinosa) FT.

Abbreviations explained.—C = Cereal; F = Fodder; M = Miscellaneous crop; FB = Fibre crop; V = Vegetables; R = Root-crop; FT = Fruit; S = Spices; O = Oil seed crop; T = Timber tree; D = Drug; De = Dye; P = Pulse crop; P.H = Pot-herb.

CHAPTER XIX.

ECONOMIC CLASSIFICATION OF CROPS.

CROPS are divided into—

(1) Cereals (C), *e.g.* wheat, buckwheat, millets, maize &c.;

(2) Pulses (P), *e.g.* gram, peas, lentils, horsegram (kulthi), pigeon-pea (arahar), cowgram (barbati), &c.;

(3) Oil-seeds (O), *e.g.* rapeseed, mustard, linseed, gingelly, niger oil seed, castor, groundnut, bhela (Semecarpus anacardium), kurunja (Galedupa indica) and pittaraj (Amoora rohituka);

(4) Fibres (FB), *e.g.* jute, sunn-hemp, cotton, musk-mallow, munj-grass, aloe (Agave Americana and other agaves), Manilla hemp (Musa textiles), Mauritius hemp (Fourcroya gigantea), rhea, *ulatkambal* (Abroma augustifolia);

(5) Dyes (De) *e.g.* indigo, safflower, arnotto (Bixa orellana), *palás*, *haritaki* (Terminalia chebula), *bahera* (T. Belerica), *ámlaki* (Phyllanthus emblica), aich or al (Morinda citrifolia) &c.

(6) Drugs (D), *e.g.* cinchona officinalis, plantago ovata (Ishapgul), acorus calamus (*bach*), tea (camelia theifera), coffea Arabica, nicotina rustica and tabacum, papaver somniferum, cannabis sativa, datura metel;

(7) Spices (S) *e.g.* turmeric, ginger, *ámádá*, chillies, onions, garlic, coriander seed, *jirá* (cuminum cyminum), anise, fenugreck (tigonella fœnum græcum), *rádhuni* (apium graveolens), *tejpátá* (laurus cassia), *sulpa* (fumaria parviflora), *peepul*, *pán*, *chai*,, *keya phul* (pandanus odoratissimus), cardamum (amomum subulatum), mint (mentha arvensis), *supári*;

(8) Table-vegetables (V) *e.g.* potatoes, brinjals, radishes, yams, gourd, pumpkin (Deshi-kumrá), bottle-gourd (Láu), snake-gourd (Chichingá), ladies' finger, country figs or Dumbur (Ficus cunia), roselle, beans, arums, Indian horse-radish,

tamato, cabbage cauliflower, Knol-kol, turnip, carrot, beet, lettuce, artichoke, Jerusalem artichoke, *palval*, asparagus, &c ;

(9) Pot-herbs or *ságs* (P.H), *e.g.*, Indian Spinash or Puin-ság (Basella alba and rubra), Kalmi-ság (Ipomæa sepiaria), Chámpá-noté-ság (Amarantus polygamus), Gobrá noté (A. lividus), Dengo-ság (A. giganticus), Pálam, Beto-ság (Chenopodium viride), Helancha ság (Hingcha repens), Shushni ság (Marselia quadrifolia) ;

(10) Miscellaneous crops (M), such as, sugarcane, Madur-káti, bamboo, Ulu, Supari (Areca catechu), mulberry, asan (Terminalia tomentosa), cucumber, melons, chufa (Scirpus kysoor), Shánkálu (Dolichos glutinosus), date (Phœnix sylvestris), Sago (Caroyta urens) ;

(11) Fruits (FT), *e.g.* Mango (mangifera indica), cocoanut (Cocos nucifera), Papaya (Carica papaya), Cashew nuts (Anacardium occidentale), etc. ;

(12) Fodder crops : (F), *e.g.* Guinea-grass, sugar-sorghum, Sorghum halipensi, latá grass, Reana luxurians, Bhringi, &c.

(13) Yams, potatoes, turnips, arrowroot, cassava, cauli-flowers, cabbages, beet, carrots, &c., are sometimes called root-crops (R). Cucumbers, melons, and water-nuts may be classed also as fruits as they can be eaten raw.

(14) Timber trees (T) can be hardly classed as agricultural crops, but the Bábul timber being largely used for making agricultural appliances and the fruits and leaves of this tree being in common use for feeding cattle, are largely grown by cultivators.

CHAPTER XX.

CHEMICAL COMPOSITION OF THE PRINCIPAL CROPS.

THE Chemical composition of crops is usually considered under six heads, viz., (1) Water, (2) Albuminoid or flesh-forming matter, (3) Carbohydrates or heat-forming matter, (4) Fibre, (5) Fat and (6) Ash. Of these Albuminoids

and fat make the richest food. Carbohydrates though less concentrated, are also highly digestible. Fibres are more or less digested by ruminant animals, but they are not a desirable component of food substances. The ash constituents of plants are not altogether useless though in estimating the feeding value of a crop, these are neglected. The bones and the ash constituents generally of the animal frame are derived from the ash constituents of plants, and hence they have a great value. Before giving the chemical composition of the principal crops it is best to give at the outset the composition of the principal articles of human food, as a guide for judging the value of all food substances and fodders.

Average composition of the commonest food substances.

	Water.	Albuminoids.	Carbohydrates.	Fibre.	Fat.	Ash.
Flesh ...	68·5	20·4	Nil	Nil	10	1·1
Fish ...	82·6	15·8	Nil	Nil	·4	1·2
White bread ...	35·4	9·5	52·8	Nil	1·2	1·1
Flour ...	12·5	11·3	74·6	Nil	1·1	·5
Average cereal	11·7	9·12	71·2	3	3	2
Average pulse	10	24	52·5	7	3·5	3
Potatoes ...	77·9	2·1	18	1	·1	·9
Turnips ...	91·7	1·1	5·3	1	·2	·7
Cabbages ...	89·5	1·5	7	1·1	·1	·8

251. *Composition variable.*—The composition of grain and seeds is tolerably constant, but that of straw, leaves, roots and tubers, varies very considerably according to the variety, soil, manure and season. The same variety of wheat, rice, maize or any other grain or seed has about the same composition, but different varieties often differ very much in composition. The hill rices, for instance, contain much more fat than the ordinary rices. With regard to fodders the chemical composition differs very much according as the crops are cut in a mature or immature condition, and also according to the process of drying they afterwards undergo. Too

much exposure to sun impoverishes them considerably. The results of analyses of the principal fodders, grains &c., are given below:—

	Moisture.	Insoluble siliceous matter.	Albuminoids.	Carbohydrates, starch, &c.	Woody fibre.	Ash.	Total nitrogen.
Fresh juár 1st cutting (October)	56·10	2·54	3·10	20·65	15·32	4·83	·565
2. Fresh juár cut in March (2nd cutting)	63·77	4·07	1·54	18·50	10·35	5·84	·419
3. Dry juár (1st cutting.)	Nil.	5·78	7·06	47·04	34·90	11·00	1·28
4. Dry juár (2nd cutting.)	Nil.	11·24	4·25	51·06	28·56	16·13	1·15
5*a*. Fresh deodhán juar, reaped ripe.	67·02	1·6	·64	16·42	12·78	3·14	·173
5*b*. Do. (dry)	Nil.	4·85	1·94	49·78	38·75	9·52	1.052
6. Commissariat hay.	11·07	6·72	2·69	45·40	32·07	8·77	·47
7. Ordinary hay (grass cut ripe.)	9·81	12·01	1·54	39·39	34·58	14·68	·261
8. Do. (Grass cut tender and green.)	9·23	10·66	2·46	44·16	31·75	12·40	·411
9. English hay	15	2	10	44	26	6	1·5
10. Sorghum halipense, reaped green.	70·96	2·2	·81	12·14	12·57	3·52	·184

	Moisture.	Insoluble siliceous matter.	Albuminoids.	Carbohydrates, starch, &c.	Woody fibre.	Ash.	Total nitrogen.
11. Sorghum halipense, reaped ripe.	67·02	1·6	·64	16·42	12·78	3·14	·173
12. Deodhán or juár grain.	9·96	·63	7·66	77·84 (including 3·40% of oil.)	2·24	2·30	1·26
13. Juár bhusá.	10·79	6·94	2·24	51·57	25·42	9·98	·484
14. Wheat bhusá.	7·56	11·77	2·37	43·06	34·68	12·33	·50
15. Barley bhusá.	7·93	6·25	4·00	41·45	34·82	11·80	·85
16. Oat bhusá	9·53	5·81	1·37	43·48	36·09	9·53	·35
17. Gram bhusá.	10·11	9·30	4·46	38·84	27·63	18·96	1·00
18. Arahar bhusá.	6·58	8·37	7·39	45·74	25·69	14·60	1·5
19. Pea bhusá	9·88	5·73	9·94	42·83	22·27	15·08	2
20. Peas ...	14·3	...	22·4	54·5 (including 2% of oil.)	6·4	2·4	
21. Oats ...	13·0	...	12·9	59·8 (including 6% of oil.)	10·8	3·5	
22. Wheat ...	14·4	...	11·3	69·6 (including 1·5% of oil.)	3·0	1·7	

	Moisture.	Insoluble siliceous matter.	Albuminoids.	Fat.	Soluble carbohydrates.	Fibres.	Ash.
23. Barley ...	14·0	...	10·6	2·0	63·7	7·1	2·6
24. Maize ...	11·0	...	10·5	5·1	68·5	3·0	1·6
25. Wheat straw.	14·3	...	3	1·5	32·6	44·0	4·6
26. Rice ...	14·5	...	6·5	0·5	76·00	1·50	1
27. Potatoes	75·0	...	2·1	·3	20·5	1·1	1·0
28. Turnips	91·7	...	1·1	·2	5·3	1·0	0·7
29. Drumhead cabbage (inner leaves.)	89·42	...	1·50	0·08	7·01	1·14	0·85
30. Carrot ...	84·0	...	3·2	...	7·2	3·1	2·5
31. Mangold	90·0	...	2·0	...	3·8	2·6	1·6
32. Linseed	7·50	...	24·44	34·00	...	30·73	3·33
33*a*. Rape seed.	7·13	...	20·50	36·81	18·73	6·86	8·97
33*b*. Do. ...	7·12	...	18·00	41·33	23·26	5·66	4·63
34. Cotton seeds.	6·57	...	22·60	31·24	...	32·72	6·37
35. Lentils (musuri.)	13·00	...	24·00	2	46·50	10·00	2·5
36. Beans ...	14·5	...	23·00	...	47·7	10·00	3·8

CHAPTER XXI.

RELATIVE IMPORTANCE OF CROPS.

THE principal crops grown in Bengal according to their order of importance are: rice, oil-seeds, jute, maize, wheat, sugarcane, *marua*, and tobacco. Other important crops which occupy comparatively less areas are, tea, indigo, mulberry, pulses (*kalai, mung, arahar* and gram), sorghum, spiked millet, oats, sunn-hemp, *pán*, potatoes, yams, *palval*, brinjal, onions, chillies, turmeric, ginger, *ságs* of various kinds, and English table-vegetables. Bamboo, thatching grass, mango, jack, papaya and plantains are also of sufficient importance to be classed as crops. We will in this Part deal only with the principal crops and also those that probably have an important future before them. Crops that may be introduced with success into the general agriculture of the country, such as rhea, cassava, arrowroot, sunflower, kulthi and carrot have a special importance. Some knowledge of such special subjects, such as, opium, lac, rubber, bee-keeping, &c. is also of importance to the student of Indian agriculture.

253. The proportion of land occupied by the first named crops will give an idea of their paramount importance. 60·5 per cent. of the cultivated area in Bengal is (*i.e.* about 38,983,000 acres) under rice; 6·45 per cent. (4,159,300 acres) under oil seeds; 3·52 per cent. (2,271,600 acres) under jute; 3·17 per cent. (2,001,400 acres) under maize; 2·28 per cent. or 1,472,000 acres, under wheat; 1·50 per cent., or 967,300 acres, under sugarcane; 1·49 per cent., or 963,500 acres under marua; and 1·13 per cent. (726,400 acres) under tobacco. 17·80 per cent. of the cultivated area of Bengal has been estimated to be cropped more than once, or about 9,739,300 acres. About 70 to 75 per cent. of the net cultivated area is occupied by the eight import-

ant crops, while 25 to 30 per cent. by all the less important crops named put together.

254. In a handbook of Indian agriculture, special importance must be attached to those crops which occupy the largest area, and we will therefore devote the following pages of this Part of the book mainly to these crops.

CHAPTER XXII.

RICE (ORYZA SATIVA).

THE *wild rice.*—Rice is indigenous to the East Indies and Australia, but cultivated from very ancient times throughout the warmer regions of the Old and the New World. Some of the wild varieties are awned and others awnless. But other peculiarities, such as ability to stand drought or inundation, are of more economic importance and should be studied by collectors of wild and cultivated species of rice. *Oryza granulata* is found on dry soils at altitudes up to 3000 feet, in Sikkim, Assam, Burmah, Paresnath and Rajmehal hills, and Malabar. It is a perennial species with an almost woody root-stock. The flavour of the grain is so good that it is collected and eaten by children. The granular structure of the inner glume is its characteristic peculiarity. No cultivated rice seems to have been derived from this wild species as this peculiarity is not possessed by any. *Oryza officinalis*, another perennial species, with a sub-woody root stock with tall and sparse branches, multi-nerved leaves and profuse branched panicles has its characters intermediate between O. granulata and oryza sativa. This wild rice occurs in Sikkim, Khasia Hills, and Burmah. Hairy glumes which are found in some cultivated rices are present in this wild species. The umbellate, naked peduncles are also sometimes met with in cultivated hill rice which is distinctly *O. Sativa*. The *O. Sativa* is

met with in the wild state wherever marshy lands occur, in Madras, Orissa, throughout Bengal, Arracan and Cochin-china. The plant is generally an annual. The inflorescence is a panicle of spikes on short peduncles which have hairy scale, frequently a distinct tuft of hairs as in O. officinalis at the point of origin of the spikes. The outer glumes are large, very often tri-dentate, midrib prominent, inner glumes variously shaped, but in the wild states considerably elongated, being as a rule, ·325 inches in length, and in the majority of cases the larger one is produced into a long awn which is distinctly articulated and possessed at its base of two glandular processes which correspond to the extremities of the lateral nerves: surface more or less hairy especially on the keel and nerves. Whilst the vast majority of forms of O. Sativa possess only one grain, certain forms have 2 or even 3 grains. The *Uri* or *Jhárá* rice of Bengal is only one form of wild O. Sativa, which may be the origin of the various *aus*, *aman* and *boro* paddies. The wild rice is hardier than cultivated rices and as it is self-sown and is easily carried from field to field, it has been sometimes known to exterminate the cultivated rice and take its place. Fishermen collect the easily detached grain by binding the ears into tufts before they are ripe. When ripe they go in their palm canoes collecting the ears or simply shaking the grain into their primitive barges. Roxburgh distinguishes between *early* and *late* rices. He distinguishes eight forms of late rice,—all awnless affording white grains. Of his early rices four are awned and yield red or coloured grains, one is awned but yielding a white grain, while three are awnless yielding white grains. Of the early rices six have coloured husks, while two have white or pale husks; of the late rices four have coloured and four white husks. The progress of cultivation is from awned to awnless and from coloured to colourless. Against these suppositions should be mentioned the fact that the O. Bengalensis or *Uri dhán* has white husk and

grain and some of the best and finest cultivated rices have awned spikelet *e.g.* the *karpurkáti*. Roxburgh's classification probably does not include the *Bilán* rices, which may have been alone derived from the wild *Uri* rice, while the ordinary red rices are probably derived from O. rafipogon and the blackish ones from O. abuensis.

256. *Area.*—It has been already said that over 60 per cent. of the cultivated area of Bengal is under rice. It is noticeable that while the Patna Division produces the largest quantity of rice, the proportion of cultivated land under rice in this Division is the smallest of all. The 15 districts that produce the largest quantities of rice and the 15 that show the largest proportion of cultivated area under rice are shown below, in order of importance :—

A			B		
Districts producing largest quantities of rice.			Districts that have the largest proportion of the cultivated area under rice.		
Name.	Estimated area.		Name.		Estimated proportion.
Lohardaga ...	2,334,600	Acres.	Balasore ...		94·39 %
Bhagalpore ...	1,614,900	,,	Birbhum ...		90·71 ,,
Mymensingh ...	1,570,000	,,	Chittagong ...		89·17 ,,
Midnapore ...	1,548,100	,,	Bankura ...		87·46 ,,
Purnea ...	1,388,300	,,	24-Parganas ...		87·16 ,,
Dinajpore ...	1,351,500	,,	Cuttack ...		85·28 ,,
Gaya ...	1,320,800	,,	Khulna ...		83·49 ,,
Backergunge ...	1,163,500	,,	Hooghly ...		81·03 ,,

A			B		
(Districts producing largest quantities of rice)			Districts that have the largest proportion of the cultivated area under rice.		
Name.		Estimated area	Name.		Estimated proportion.
Hazaribagh	...	1,157,900 „	Burdwan	...	80·38 „
Cuttack	...	1,149,600 „	Backergunge	...	80·37 „
Tippera	...	1,127,900 „	Noakhali	...	79·79 „
Burdwan	...	1,101,000 „	Dinajpur	...	79·02 „
Champaran	...	1,092,000 „	Lohardaga	...	76·14 „
Darbhanga	...	1,074,400 „	Midnapore	...	74·40 „
Faridpur	...	1,043,800 „	Faridpur	...	73·94 „

257. The *varieties* of rice recognised in Bengal alone are innumerable. Dr. Watt as Reporter of Economic Products had occasion to examine 4,000 varieties of Bengal rice at one time. Of the rices grown in the Burdwan Division the following *aman* varieties may be mentioned as suited for *bil* lands: (1) Atirang, (2) Hatishal, (3) Sada ora, (4) Megi, (5) Rupshal, (6) Ora, (7) Paramayushal, (8) Ora-megi, (9) Chilerangi, (10) Bankmal, (11) Uttarkalma, (12) Lal ora, (13) Shankchur, (14) Dhukilata môl, (15) Kanakchur, (16) Uri, (17) Lakshmi-bilash, (18) Muktashal, (19) Sindurtupi, (20) Bhut-kaurabi, (21) Páshákáti, (22) Soura, (23) Rati-Ramshal, (24) Nilkanthashal, (25) Kal-bayra, (26) Páni-kalma, (27) Shol-paná, (28) Paramananda (29) Amán, (30) Nádángháta,

(31) Sambarà, (32) Kaláshal, (33) Mete-kuji, (34) Nilratan, (35) Nilkantha, (36) Boyal dánr, (37) Uré shal. Of the above the following peculiarities may be noticed: (1) Hatishal paddy has a very big grain, though the yield per acre is not exceptionally high. It goes up occasionally to 36 or 40 maunds per acre. (2) The yield of the following varieties is large. Atirang, Sada ora, Megi, Ora, Boyal dánr, Chile-rangi, Bankmal, Uttar-kalma, Lal ora, Dhuki-lata-môl, Uri, Lakshmibilash, Sindurtupi, Bhut-kaurabi, Pashakati, Soura, Ratiramshal, Kalbayra, Panikalma, Shol pana, Amán, Nádángháta, Sambará, Kalashal, Mete-kuji, and Nilkantha, are expected to yield as much as 45 to 50 maunds per acre. (3) Paramayushal, the yield of which often goes up to 20 to 30 maunds per acre is a sweet-scented variety considered to be very easily digested and highly valued for this reason. The grains of this variety are not very fine. (4) Kanakchur, the yield of which may also come to 20 to 30 maunds per acre is valued because *khai* is made out of it.

258. Of *aman* paddies suited for ordinary paddy land (not *bil* land), the following Burdwan varieties may be mentioned as noted for special virtues: (1) Gobindabhog, Khákhkháni, Bansmati, Benaphuli, Kamini, and Badshabhog, are fine and scented varieties, which are highly prized. (2) Paramannashal and Randhunipagal are also scented varieties but not very fine. (3) Harinakhuri and Bankchur, are paddies out of which *khai* (pop-corn) is made. (4) Khejurchari the inflorescence of which has some resemblance to a bunch of dates; and (5) Pakshiraj, a peculiar looking paddy, which is supposed to have medicinal properties. (6) Chhota-bangotá, Chhanchimol, Bánkui, Harinakhuri, Dhale-kalmá, Kali-kalma, Jhingashal, Ajan, Kate-noná, Lál kalma, Lata-mol, Chhota-dhole, Chhanchiorá, Jatá-kalmá, Dudhe-noná, Hara-káli, Mánik-kalmá, Kártikshál, Kártik-kalmá, Khepá, Rángibangotá, Nadna-shal, Mehupal, Jal-shuka, Altapati-nona, Mugurshal, Dhole, Shunnógangajal, Mota-nagra, Bangota Patalegara, Dhukishal, Kash-

phul, Nona, Laushal, Kalmá, Gádháshál, Dudh-kanrá, Kalamkáti, Laushenkátá, Sindurmukhi, Bankátá, Chámpáshál, Neulipátuni, Bári-ámla, Máchiyán, A'kindi, Bagi-lal-pátuni, Leajkata, Sondálmukhi, Noyáchur, Khayershál and Noyan, are heavy yielders. The superior fine and scented rices are produced in only about half the quantity of the coarser kinds.

259. Peshwari rice which is a highly absorbent variety and in great favour with Mahomedans, has been successfully grown in Burdwan in high lands suitable for growing *Aus* paddy. High class Aman paddies also grow best on land which does not get too much under water. On land too wet fine rices show a tendency to become coarse. At the Sibpur Farm, the Kátáribhog paddy of Dinajpur is steadily becoming coarser and coarser; but the Samudrabáli variety of Bhagalpur, the finest variety of all has remained fine so far.

260. The *Aus rice* of Bengal is all coarse, difficult to digest and eaten by the poorer classes alone. It is grown on highlands and sandy banks of rivers and requires much less water than the ordinary Aman and Boro rice. As the sowing is ordinarily done broadcast it is more troublesome to grow than the Aman. It yields a smaller outturn and fetches a lower price. But it supplies the raiyat with a food grain and fodder (in common with other inferior grains, the millets, maize &c.) at a time of the year when these get scarce. When the rainy season is of short duration and the *Aman* fails, poor people depend for their subsistence on the *Aus* and the millets. The growing of *Aus* paddy, millets and maize is therefore highly advisable as a provision against famine, and the introduction of a fine variety of *Aus* more palatable and easily digested would be a great improvement. The possibility of growing very fine *Aus* rice has been demonstrated at the Sibpur Farm. It is curious this *Aus* paddy yielded a second cutting. From $\frac{1}{1\frac{1}{2}}$th of an acre 34 seers of paddy

and 52 seers of straw were obtained from the first cutting and 9 seers of paddy and 20 seers of straw from the second cutting. Thus the yield per acre of this variety of *Aus* paddy was nearly 13 maunds per acre while the yield ordinarily obtained is 15 or 16 maunds. The growing of *Aus* paddy is also desirable owing to the opportunity it gives for early preparation of land for *rabi* (winter) crops, such as pulses and oil seeds. Potatoes and *sugar-cane* which are sown later are also benefited by a longer preparation. There are some varieties of Burdwan *Aus* paddy, such as Niali, Kele, A'swingota, Kartiksal &c., which form a sort of a connecting link between the *Aus* and the *Aman*. These are also transplanted like *Aman*, and require more water than the *Aus*. The time of transplanting these is somewhat later than that of ordinary *Aus*, but they are reaped a month or two before the *Aman* which is a great advantage.

261. *Rotation.*—*Aus* grown on *dearh* land is often followed by another cereal crop such as wheat or barley. Potatoes and *Aus* paddy form a rotation in parts of the Burdwan Division. The following rotation is recommended.

First year.—*Aus* paddy followed by a pulse or oil-seed or the two mixed together.

Second year.—Jute followed by a pulse or oil-seed or the two mixed together.

Third year.—*Aus* paddy followed by sugar-cane.

Fourth year.—Sugar-cane followed by *Aus* paddy.

Fifth year.—Potatoes followed by *Aus* paddy.

Sixth year.—Bare fallow.

262. *Aus* paddy is considered the best *cleaning crop*, as it eradicates *ulu* (Imperata arundinacea) and other weeds. When an orchard has to be made on foul *ulu* land, *Aus* paddy is sown and in the midst of the standing crop, plantains and other fruit trees are planted.

263. *Manuring.*—*Aus* paddy is often grown with manure. It is also largely grown without manure on river

sides where there is silt deposit. The manures used are cowdung, ashes, tank-earth, and rarely oil-cake. Whatever quantity of dung the raiyat gets hold of or can afford to apply, he applies and there is no rule observed as to quantity. The application benefits the subsequent *rabi* crop also, and it is for this reason that *Aus* paddy is heavily manured. *Aus* crop grown after potatoes is not manured. 250lbs. (1 maund per bigha) of oil-cake per acre is the usual quantity used, when this manure is applied. Tank-earth is applied once in 3 or 4 years, 30 to 100 cart-loads per acre. 80lbs. of bone-dust and 80lbs. of saltpetre per acre would be a good substitute for oil-cake, and would give more yield. The cost would be Rs. 6 or Rs. 7 (*i.e.*2 or 2·8 for 80lbs. of bone-dust and 4.4 or 4·8 for 80lbs. of crude saltpetre). The outlay will be more than realised by increased outturn. The bone-dust should be applied at the time of cultivation and the saltpetre after transplanting mixed up thoroughly with the earth along the grooves made for transplanting.

264. *Soil.*—The soil considered best for the *Aus* paddy are loam, sandy loam and loamy sand, situated rather high.

265. *Tillage.*—The first ploughing and cross-ploughing should be done in the cold weather or as soon after the *rabi* harvest as possible. If the land is too hard to plough, ploughing should be done after the first shower of rain in February or March. The longer the interval allowed between the first ploughing and the sowing the better, hence the importance of doing the ploughing as early as possible. The plough need not be used after the first ploughing and cross-ploughing, but the *bakhar* may be substituted in its place twice or three times, as occasion will arise, for killing the weeds and preparing a seed-bed. The burning heat of summer will destroy the weed and leave the land clean. Six or seven ploughings are not required if one ploughing and one cross-ploughing are done early in the season. Later, after a fairly heavy shower of rain two successive bakharings followed by

harrowing and laddering will level the land. Sowing should be done by drilling, but transplanting is still better even for *Aus*. If sowing is done broadcast or by drilling, a light wooden roller should be used to cover the seed and give the land the proper compactness. A rounded log of wood or a beam can be used as a roller. The transplanting should be done at intervals of 9 inches, two or three seedlings being planted at each spot. The seed-bed for *Aus* paddy should be close to water, that it may be kept watered and transplanting done at the very commencement of the regular rainy season, say, about the 15th or 20th of June. The sowing in seed-bed or in field should be done early in May, and the first heavy shower of rain from the middle of April to the middle of May may be utilized for this purpose, *i. e.* for final preparation of land and sowing. 15 seers of seed are ample for one acre if transplanting is done. If sowing is done broadcast 30 srs. of seed per acre are required; if drilled 20 srs. will be found sufficient. For seed-bed 3 mds. per acre may be sown. Transplanted paddy (if transplanting is done early, *i. e.* when the plants are only about 9 inches high) grows more vigorously than paddy grown from broadcasted or drilled seed. Transplanting also gives facility for the after-ploughing operation, or hoeing, or running the spade in lines and overturning the soil, either of which operations gives vigour to the plants. This ploughing with a small plough called *lánglá*, or hoeing, or spading, should be done when the transplanted seedlings are well established. Seedlings can be kept even 3 or 4 days after uprooting them with impunity, but it is safe to have the bundles of seedlings in damp and shady places, or actually in water if they cannot be planted out at once. The produce of each *cottah* of seed-bed is made into 30 or 32 bundles. The tops of the bundles should be cut off before each is untied and the planting out is done. Before transplanting, water should accumulate in the field and ploughing in puddle should be done. The ladder should be

also passed over the puddle. But in sandy soil laddering of puddle before transplanting is not necessary. The seed should be sown early in the season in light showery weather, as the caking of the soil after a heavy shower of rain prevents free germination. Broadcasted *Aus* seedlings when they are about 9 inches high are harrowed with a *bidiá*. It is an operation which does as much harm as good and it is not recommended. The harm done by the uprooting of seedlings is not very noticeable as a great deal more of seed is used than is necessary. The hoeing and weeding done by the *Bidia* is very imperfect. Passing the bullock-hoe, or the wheel hand-hoe, or the *lángla*, or the spade, along straight drills, is much better.

266. *Irrigation.*—If the soil looks dry especially when the plants are coming to ear irrigation should be resorted to. Irrigation at this the *thor-mukh* stage of growth results in heavy yield, unless seasonable showers make irrigation superfluous.

267. *Harvesting.*—*Aus* paddy should not be allowed to get too ripe. It sheds more easily than *Aman* paddy. End of September is the usual time for harvesting but early varieties (Sháti, &c.) are harvested, as early as August. *Aus* straw is also more brittle than *Aman* straw and it easily gets broken. This is another reason for cutting *Aus* while it is still somewhat green. The corn is cut close to the ground and left in parallel lines in the field for about a week. Afterwards sheaves are made and 100 to 150 sheaves stooked together and gradually removed and threshed in the threshing floor.

268. *Outturn.*—The outturn per acre of paddy is 12 to 25 mnds. and of straw 10 to 20 puns (20 to 40 mnds).

269. *Diseases* will be treated separately in the Part devoted to Insect and Fungus Pests.

	per acre.
Cost.—1 ploughing and 1 cross-ploughing, with laddering @ 12 annas	1 8 0

2 bakharings with laddering or rolling ...	0	12	0
1 ploughing in puddle	0	12	0
6 men employed in transplanting seedlings	1	3	0
Proportion of cost for seed nursery ($\frac{1}{15}$th)...	0	8	0
Cost of 15 seers of seed @ 2Rs. a mnd. ...	0	12	0
3 mnds. of powdered oil-cake 6-0 or 1 mnd. of bone-dust 2-8 } say ... and 1 mnd. of crude saltpetre 4-0	6	8	0
Cost of applying the same	0	6	0
Cost of turning up the soil with spades (15 men)	2	13	0
Reaping, 6 men	1	2	0
Binding and carrying, 6 men ...	1	2	0
Threshing (with threshing machine, 4 men employed for 2 days) and winnowing ...	1	8	0
Rent (half calculated against *Aus* crop) ...	1	8	0
	20	6	0
Yield.—Paddy, 20 mnds. ... ... Rs.	20	0	0
Straw, 10 puns, say, 25 mnds. ... ,,	3	0	0
Rs.	23	0	0

The net profit thus comes to less than Rs. 3 per acre. But the 20 mnds. of paddy may sell for as much as Rs. 40, and with such heavy manuring with saltpetre and bone-dust, one can expect even more than 20 mnds. of paddy per acre. If a fine variety is grown the yield will come to about 12 mnds. per acre, but the money-value will be about the same.

270. *Husking.*—Husking the paddy after steaming, 20 mnds. should give at least 14 mnds. of rice, and the cost of husking (3 women doing 2 mnds. a day at a cost of 7 annas per mnd. of rice) may be calculated at about Rs. 6. 14 mnds. of *Aus* rice at Rs. 2 a mnd. may be valued at Rs. 28, this adding to the net profit another Rs. 2 per acre.

271. *Aman paddy.*—Most of the remarks and calculations

about *Aus* paddy apply to *Aman* paddy also, and it is only the distinctive characters of this crop that will be described here.

272. *Soil.*—Lowlying clay soils are preferred for this crop. High lands which cannot be easily irrigated are not suited. The fine varieties specially are supposed to need to be under 6 inches or 9 inches of water from the time of transplanting to that of the plants coming to ear; but the need for a large accumulation of water at the base of the fine varieties of *Aman* has been much exaggerated. In light soils *Aman* paddy is sometimes sown broadcast. It is a lazy system which is prevalent in the southern portion of Murshidabad and northern portion of Nadia and perhaps in other parts of Bengal also.

273. *Cultivation.*—The land should be ploughed and cross-ploughed immediately after the previous *Aman* harvest, if feasible *i.e.*, in December. Time should not be wasted allowing the land to get too dry for ploughing. If the land has become too dry already a shower in January or February should be taken advantage of in ploughing up new fields. If *kalâi* or any *rabi* crop follows the *Aman* crop, the first ploughing and cross-ploughing should take place in March or April, *i.e.*, as soon as there is a shower of rain following the *rabi* harvest heavy enough to allow ploughing of the land. At the beginning of the rainy season, or a little earlier, *i.e.*, about the end of May, if possible, seed is to be sown in properly cultivated seed-beds. The paddy fields should undergo regular cultivation after the commencement of the rains, ploughing being done in puddle. The object of this is to bury the grasses and weeds. Two ploughings and two cross-ploughings followed by one laddering in each case, are enough for the field to receive seedlings.

274. The method of transplanting is the same in the case of *Aus* and *Aman*, only in the latter case, transplanting is done later. *Aus* paddy is commonly sown broadcast and no transplanting is done. The earlier the transplanting can be safely

done the better it is for securing a good outturn. The seed-bed can be kept in a flourishing condition by irrigation if necessary in June, and transplanting can be commenced when the regular rainy season just sets in *i.e.*, about the first week of July or earlier. If transplanting is put off to August because there is not sufficient accumulation of rain-water, the result will be poor, and need for irrigation may be felt if the rains stop early in the season. Early preparation and early transplantation are a great security against failure. The reports of the Meteorological Department should be closely watched at this season; but the preparation of the seed-bed should on no account be put off to the regular commencement of the monsoon. It is better to resort to irrigation to keep seedlings alive, if necessary, early in the season. So instead of sowing seed in July as is usually done, sowing should be done by the beginning of June and transplanting by the end of June, instead of in August. In unusual years, there is sometimes no rain till the end of June and beginning of July. In such years preparations must perforce be delayed, but in this case it is advisable to drill paddy seed in fields instead of sowing it in seed-bed and afterwards transplanting the seedlings. This saves time, and time is of the greatest importance when the rainy season threatens to be a short one. At such a season it is advisable also to grow as much *Aus* paddy, maize and millets, as the high lands will carry.

275. *Manuring.—Aman* land is seldom manured, but manuring with oil-cake, at 3 maunds per acre would certainly give a better yield, and pay for the outlay by the increased outturn. Where the accumulation of water is too great, and surface drainage too free, oil-cake, or dung, or tank-earth should be applied in preference to saltpetre.

276. *Aman* paddy need not be thrashed soon after harvesting, but kept stacked for months.

277. The *flood* of September 1900 enabled me to find out that of the superior varieties of *Aman* paddy the following

stood the flood remarkably well, *viz.*, Karpursal, Kéléjira, Samudrabáli and Mohanbhog, the first three being scented varieties and the third and particularly the fourth, prolific varieties. The seed of Kéléjira is black, small, but long; of Samudrabáli, dark brown, small and short, and of Karpursal light coloured and small but long. After the water subsided the plants of these three varieties after being 12 days under water yielded a crop as if nothing had happened. The grains of Mohanbhog are light coloured and large. It is an Eastern Bengal variety and very prolific. This also came out of the flood unscathed, while most other varieties perished or suffered more or less in the immediate vicinity. Seed of these varieties should be kept up at the Sibpur Farm.

278. The proportion of grain to straw is higher in the case of *Aman* paddy and the absolute yield is also larger, as much as 40 or 50 maunds of grain per acre being often obtained. The net profit per acre is therefore larger in the case of *Aman* paddy. Rs. 10 to Rs. 15 of net profit per acre may be expected by an intelligent cultivator adopting proper methods.

279. *Boro-paddy.*—This is a comparatively minor crop. Two successive crops of *boro* paddy may be obtained in a year, one being cultivated as a *rabi* or winter crop and the other as a *kharif* or rain crop. The *kharif* variety is sown in the seed-bed in June or July transplanted in July or August and harvested in September or October. The *rabi* variety is sown in seed-bed in October or November, transplanted in November or December, and harvested in May. The *kharif boro* is grown with the aid of artificial irrigation. A low lying and soft piece of land by a river or *bil* side is chosen for seed-bed. If necessary the land is flooded artificially before it is ploughed. The seed is sown on soft mud but not in water. Newly thrashed grain is used. For 3 days and nights the grain is alternately dried in the sun and exposed to the night dews. It is then put in a bag which is kept under

water all the night and dried all the day. This process is repeated for 3 days and nights. If the seeds have all germinated by this time they are immediately sown. Otherwise they are filled into a bag and covered with blankets. After a day or two the seeds are taken out and broadcasted in the nursery at the rate of 4 maunds per acre. The seedlings from an acre are sufficient for 8 or 10 acres. After the seedlings are 2 inches high, the nursery is watered once a week. They are transplanted when 8 or 9 inches high. After transplantation the field is kept irrigated when necessary till harvest time. The *rabi boro* is grown in lowlying fields where there is water in October or November. No ploughing is needed in such lands which are usually soft, and seedlings are simply transplanted when 10 inches or 12 inches high into the soft mud. One or two ploughings are given when the land is not quite soft. All that is needed afterwards to the time of harvesting, is pulling out of weeds and burying them in the soft mud.

280. The *outturn* of *boro* paddy is 20 to 25 mnds. per acre. The winter variety gives a better outturn.

281. In most districts *boro* is broadcasted only in November and December or even January and February, and harvested in April and May or in June. *Boro* is sometimes transplanted, 2, 3 or 4 times, between December and February.

282. *Boran Aman or Long-steamed Aman.*—These are coarse varieties of *Aman* which habitually grow in water 5 to 15 ft. deep. They are sown broadcast in *bil* or lowlying lands. As the water rises the plant also grows, growth of as much as 9″ to 12″ in 24 hours at the beginning of the rainy season having been observed. When submerged through a sudden flooding for more than 3 days, the crop is completely destroyed. This accounts for the failure of the experiment in the growing of the long-stemmed paddy in the Argoal Circuit of Midnapur. The sowing and harvesting take place at the same time as the sowing and harvesting of

ordinary *Aman*. Only the ears and a foot or two of straw are harvested. The rest of the straw is used for fuel or gathered and burnt.

283. *Ráydá*.—A peculiar kind of *boro* rice is known as *ráydá* or *bhásá-nárángá*. This is sown along with ordinary *boro* rice in December. The young stems are shorn when the *boro* crop is removed, but this does not seem to do the *ráydá* any harm. It continues to grow attaining a height of 10 and even 20 ft. and is not harvested till September or October, thus remaining on the land for 10 months. Only the ears with a foot and a half of straw are harvested, the rest of the straw or *nárá* being left to rot on the land, or gathered and set fire to.

284. *Aus, boro* and *ráydá* paddies supply the food of the poorest people of Bengal. Fully one third of the whole produce of Dacca belongs to the *Aus* and *boro* classes of rice, and even the *Aman* paddy of Dacca especially the long-stemmed variety, is a coarse and inferior grain. *Ráydá* is also grown in Eastern Bengal.

285. The most *favourable climatic conditions* for the rice crop are: (1) Premonitory showers in May facilitating preparation of land and sowing in seed-beds; (2) Heavy showers at the end of June and July, facilitating transplantation; (3) Fair weather for a fortnight in August facilitating weeding operations; (4) Heavy rains in September when the *Aman* is coming into ear; (5) Casual but heavy showers in October about once a week especially during the first fortnight; and (6) One or two good showers at the end of January facilitating ploughing up of rice land in cold weather. The *Aus* crop does not need such a heavy rainfall, nor late rainfall, as the *Aman* does.

286. *Average Outturn*.—The outturn differs so much in different districts and for different varieties that it is difficult to strike an average. Sir W. Hunter gives 15 maunds of clean rice per acre as the average yield, while Sir A. P. Macdonell

gives, 10 maunds of rice for *Aman* and 8 maunds of rice for *Aus* and *boro* as the average yield per acre. About 12 mnds. or 1000 lbs. of rice, or 16 mnds. of paddy, is probably a better estimate of average yield per acre.

287. The harvest of December 1900 at the Sibpur Experimental Farm gave the following results with regard to outturn of different races of fine and coarse varieties of paddy, grown on different classes of land without manure :—

	Produce of grain per acre lbs.	Produce of straw per acre lbs.
1. Bádsábhog (fine scented *Aman*) grown on proper *Aman* land *i.e.* low land ...	2,600	4,400
2. Bádsábhog grown on high land suitable for *Aus*	930	1,640
3. Bádsápasánd (fine scented *Aman*) grown on *Aus* land	710	1,980
4. Ránipágal (fine scented *Aman*) grown on *Aus* land	580	1,020
5. Rándhuni-págal (fine scented *Aman*) grown on *Aus* land	750	1,020
6. Chinor (very fine scented *Aman* from the C. P.) grown on *Aus* land ...	400	710
7. Bánsphul (fine *Aman*) grown on *Aus* land	930	2,000
8. Dáudkháni (*Aman* for ordinary table rice) grown on *Aus* land	1,270	2660
9. Kanakchur (fine *Aman*) grown on *Aus* land	720	1,320
10. Karpurkáti (scented *Aman*; awned, fairly fine) grown on *Aus* land ...	700	1,640
11. Samudrabáli (very fine and scented *Aman*) grown on *Aus* land ...	500	820
12. Kátáribhog (fine *Aman*) grown on *Aus* land	1,175	1,430
13. Hatishal (coarser *Aman*) grown on *Aus* land	820	1,880

14. Very coarse, awned, *Aman* paddy grown on *Aus* land	1,200	4,480
15. Very fine *Aus* paddy grown on *Aus* land	1,014	1,476
General average ...	953¼	1898½

i.e. roughly 12 maunds of paddy and 24 maunds of staw per acre. The general average of this farm for the three previous years was 1,208 lbs. of grain and 3000 lbs. of straw. As out of the fifteen varieties grown only two were coarse, and as nearly all the varieties were grown on unsuitable land, the averages struck are too low. Probably 16 maunds would be a fairer average than 12 for grain, and 30 maunds for straw. The produce of Bádsábhog, which is a fine and scented variety, obtained from a lowlying field where there was water throughout the growing period, shows what the possibilities are. The outturn actually obtained represents a produce of over 30 maunds of grain and over 50 maunds of straw per acre. The *ráiyat's* expectation of 50 maunds per acre in the case of coarse paddy, is not, therefore, altogether vain. The figures given above show how difficult it is to arrive at a fair average, and unless a fair average for each subdivision and district is arrived at, it is not possible to estimate the potential food-stock of the country.

288. *Mixed rice crops.*—The mixture of *boro* and *ráydá* paddies has been already mentioned. *Aman* and *Aus* are often grown mixed in the same field. When a mixed crop like this is grown, usually a full crop of *Aus* and only a 12-anna crop of *Aman*, is obtained, if everything goes well. But if there is short rainfall early or late in the season, one or the other crop fails more or less. 36 srs. of *Aus* and 18 srs. of *Aman* seed are sown broadcast together per acre. The sowing is preceded by a ploughing and followed by a ploughing and 2 ladderings. After the seeds have germinated the field is once ploughed and twice levelled with the ladder. The ladder is used again

a week after. The *bidia* or bullock-rake is also passed and one or two hand-weedings given afterwards. It is obvious that this rough treatment is withstood only because such a large quantity of seed is sown broadcast in an irregular manner.

289. The description of rice cultivation in the Sunderbans, given in Dr. Watt's Dictionary, is of considerable interest, and should be studied by those who have any intention of taking up lands in the Sunderbans.

290. *Chemical Composition.*—Rice is deficient in mineral and nitrogenous matters. The average composition is—

Water	... 13%
Ash	... 1 „
Fat	... 1 „
Nitrogenous matter treated as albuminoids	7 „
Fibre	... 1½ „
Starch	... 76 „

Glutinous rice has not any more N than ordinary rice. Rice contains a higher proportion of P_2O_5 but a lower proportion of K_2O and N than wheat. The husk of rice contains a great deal of SiO_2, and is of little feeding value; but the *kunrá* or rice-dust is richer than rice in feeding value, the average composition of this substance being—

Water	... 11%
Ash	... 9 „
Fat	... 14 „
Nitrogenous matter treated as albuminoids	13 „
Fibre	... 8 „
Starch	... 45 „

Containing a high proportion of oil, *kunrá* gets rancid by keeping and it should be therefore used as fresh as possible.

The water in which the rice is boiled renders the cooked rice still more deficient especially in ash constituents than uncooked or steamed rice.

CHAPTER XXIII.

PADDY HUSKING.

PADDY is safer to store in godowns for a long time than rice. But even rice can be stored free from weevils and other pests if carbon bisulphide is used, say 1lb. for every 20 maunds of rice stored in air-tight vessels, such as *jálás* tarred inside and out and covered with *sharás* sealed up with cowdung paste after the *jálás* have been filled with rice.

292. The husking of paddy should be deferred for 7 or 8 months after harvest, but if steaming is done very little breakage takes place even in the case of new rice. As a precaution against famine, the *storing of new paddy* for about 8 months before husking and sale of rice are undertaken, should again come into fashion, as it used to be in olden times.

293. The *ordinary method of husking* paddy with *dhenkis* or pestles and mortars, is too well known to need description. Of all the mechanical appliances in use in the New and the Old worlds, the Rice Huller and Polisher manufactured by the Engelberg Huller Co. of Syracuse, New York, has attained the most well-deserved popularity. There are several mills in Southern India and in the Punjab where this 'Huller and Polisher' is in use, and two of these machines have been lately set up at Manicktalá near Calcutta. The Rice Huller and Polisher manufactured by Messrs. S. Howes and Co. of London is a machine which scarcely differs from the Engelberg Rice Huller and Polisher; and Ghatak's Rice Huller is only a cheap and inefficient imitation of these machines. With Ghatak's hand-power (or foot-power) paddy-husking machine, fine paddy has to be put through the mill at least 12 times before complete husking takes place.

294. *Ghatak's bullock-power paddy-husking machine* as modified and sold by Messrs. Burn and Co. for Rs. 60 only, is well adapted for use in jails and also for famine operations. The rice from this mill gets somewhat broken, and there is a larger proportion of paddy in it even after three turns, than in ordinary bazaar rice. At a trial held at Messrs. Burn and Co's workshop at Howrah on the 12th January 1901, the following information was compiled:—The trial lasted for 2 hours exactly. The paddy used was new paddy of the Kátáribhog variety grown at Sibpur. It had been properly steamed and dried. The quantity used for a full charge was 29 seers. Instead of 2 bullocks, 8 men were employed at the shaft and one man for feeding the mill. The paddy came out at the vent at the bottom only partially husked, the first time. It had to be run through the mill twice more before satisfactory result was obtained. The rice obtained at the third turn weighed after winnowing 17 seers. The winnowing machine, which is quite a separate machine, is priced Rs. 65. It does its work very well and it is capable of winnowing 40 to 50 maunds of rice per day.

295. The mill looks from outside like an ordinary *ghâni* or *kalu* (oil-mill). The vertical cylinder worked by the bullock-shaft has attached to it three sets of slanting vanes. The cylinder is kept in position by rings joined to the outer cask of the mill by three sets of bars. The paddy in working its way down from the hopper through the bars into the vent is subjected to the squeezing action of the vanes. It is by this action that the husk gets detached from the rice, in the same way as the detachment takes place if paddy is rubbed or squeezed between the palm and the thumb.

296. *Comparing the cost* of husking paddy with *dhenki* with that of husking it with Messrs. Burn and Co's mill, it will be found, that there is some advantage in favour of the latter for husking coolie rice, *i.e.* coarse rice for consumption by poor people. The 29 seers of paddy filled the mill at

first, but as the twisting action went on the volume steadily diminished. The trial would have given better result if the mill had been kept filled up by a continuous supply of paddy or partially husked rice. From the trial itself however it could be inferred that each maund of rice would cost about 4 annas husking with this mill. The wages of 1 man for 2 hours may be taken as 9 pies and the cost of keep of a pair of bullocks for $\frac{1}{4}$th of a day as 1 anna. 17 seers of rice costing 1 anna 9 pies, each maund would cost about 4 annas, exclusive of the cost of steaming and drying the paddy. One woman can steam and dry 3 maunds of paddy per diem from which with *dhenki* 2 maunds of clean rice is obtained. So the cost of steaming and drying per maund of rice turned out is put down at one anna. To husk 3 maunds of paddy with *dhenki* 6 women are required. Thus the wages of 7 women, *i.e.* about 14 annas, are needed for obtaining 2 maunds of clean rice. So the difference in favour of Messrs. Burn and Co's system is 2 annas per maund of clean rice. The rice turned out is however somewhat inferior to ordinary bazaar rice, and if this makes a difference of 2 annas or more per maund, there is no advantage in introducing Messrs. Burn and Co's machine. But, as already pointed out, continuous feeding would have considerably diminished the cost.

297. As to the *quantity* that the machine turns out *per diem*, on the 17 seers basis, we can expect only 68 seers per day of 8 hours, as it is not feasible to work bullocks for more than 8 hours per day. Even with continuous feeding probably not more than 3 maunds of clean rice could be expected per day. If it does this much, the cost of husking comes to only about 2 annas per maund of clean rice, which is a great improvement over 7 annas per maund which is the average cost of husking with *dhenki*. If, however, instead of 2 bullocks, 8 prisoners are employed in jails for husking paddy with Burn and Co's mill, the advantage in its favour will disappear.

298. A rice-mill driven by a portable engine and turning out 140 mnds. of white rice per day is also advertised by Messrs. Burn & Co., for Rs. 7,700, the engine and the paddy-smutter being priced separately. Messrs. Balmer, Lawrie & Co., of Calcutta have another rice mill. It can be worked either by hand-power or by steam. Worked by hand it is said

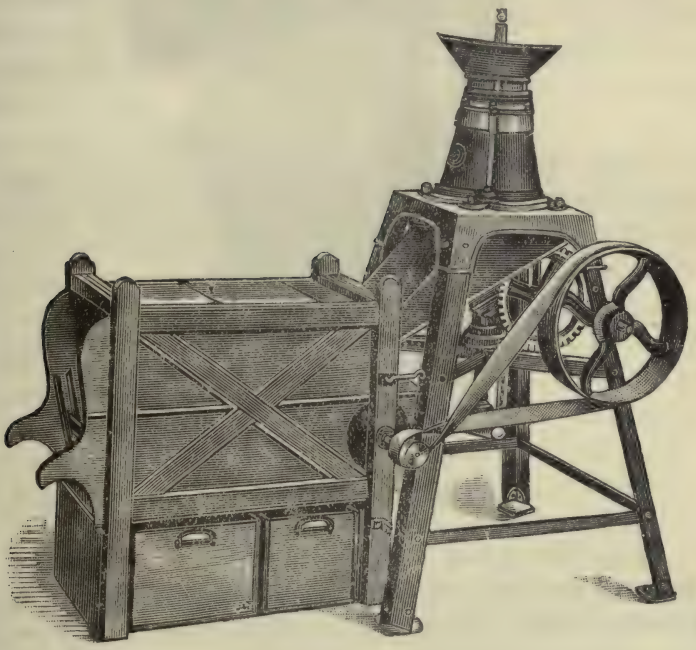


FIG. 54.—BALMER & LAWRIE'S PADDY-HUSKER.

to shell about 2 maunds of paddy per hour, and by steam, about 4 maunds per hour. The machine (Fig. 54) consists of a cone made of stone, revolved by a shaft inside a conical case, the interior of which is constructed so that a slightly corrugated surface is opposed to the stone cone. The grain passing between the two surfaces is subjected to an action similar to that of rubbing between the hands, which loosens and removes the husk with very little breakage. The

rice with husk falls inside a blower whence the rice comes out fairly clean. The price of the machine is Rs. 520.

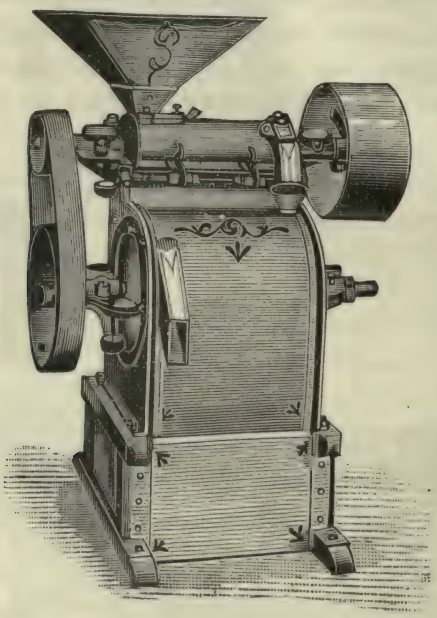


FIG. 55.—ENGELBERG HULLER.

299. The "Engelberg" Rice Huller (Fig. 55) an American machine sold by Messrs. Macbeth Brothers & Co., of 2, Pollock Street, Calcutta, and which has been recently exhibited at work at Manicktalá. yields 300 lbs. of cleaned rice per hour. It is capable of dealing with fine as well as coarse varieties of paddy, both unsteamed and steamed, and the husking is done completely in one operation. The machine itself, without the oil or steam engine required to drive it, weighs only 500 lbs. and it occupies a superficial space of 3 ft. square. The power required to drive it is about 4 H. P., and with a 16 H.P. engine a set of 4 machines can be worked. For a single machine an oil-engine without a boiler is quite sufficient, and being driven direct by a belt from the engine, the arrangement is very simple to manage. If a special mechanic

is employed to look after the engine and the paddy-husking machine, it is best to employ a set of 4 or 5 machines driven by a 16 H.P. steam-engine furnished with a boiler. The cost of a single huller is Rs. 1,100, of a separating fan or winnower for taking out the dirt, sticks, straw and stones from the paddy, Rs. 125; and of a grader for separating rice of different sizes, Rs. 100. A 12 H.P. (nominal) engine (which usually generates 15 to 16 indicated H.P.) can be bought in Calcutta for about Rs. 5,000, and 4 sets of huller would cost Rs. 4,400. Thus for about Rs. 10,000 the whole plant (exclusive of buildings) can be set up.

300. The cost of working the engine will consist of, (1) the price of coal used, (2) the wages of the mechanic and an attendant to the hullers and (3) price of oil used for lubricating the engine and huller. If there is a well or tank near at hand there should not be any extra expense in keeping the boiler supplied with water. The expenditure of coal used may be put down at 4 lbs. per H. P. per hour, which for a 16 H. P. engine working for 9 hours a day, is equal to $4 \times 16 \times 9 = 576$ lbs. or about 7 maunds costing about Rs. 2-8. The wages of the mechanic may be put down at Re. 1 a day, and of the attendant at 5 annas a day. Inclusive of oil the daily cost will thus come about Rs. 4. Interest and depreciation at 10% calculated on the capital of Rs. 10,000 will come to another Rs. 5 per day, if the work of the machine is distributed over 200 days in the year. The outturn per hour from 4 sets of hullers being 1200 lbs., daily, 10,800, or say, 10,000 lbs. of clean rice can be obtained. So the cost comes to less than a Rupee for every 1000 lbs. (about 12 mnds.) of cleaned rice turned out. This is at least four times cheaper than the rate at which paddy-husking can be done with the ordinary native appliances.

301. The Engelberg Rice Huller and Polisher No. 3 the cost of which at Syracuse, New York, U. S. A., is $150 (say

Rs. 450, or Rs. 550 landed in Calcutta), meets the demands of smaller capitalists or farmers who do not require to shell such a large quantity of paddy as indicated above. Not being such a powerful machine as the Hullers Nos. 1 & 2 which are adapted for steam-power, the paddy used for Huller No. 3 must be free from sticks, straws and grit. It requires two horse-power to drive it, and a high-speed horse-gear may be employed for the purpose. The Engelberg Huller Company supply such horse-gear for 65 dollars. Two pairs of powerful Hissar bullocks may be employed to drive it instead of two horses. The outturn of clean rice per hour from this huller is about 70 lbs., which is equivalent to about 7 maunds per day. The whole of the capital outlay inclusive of bullocks (but exclusive of the building or shed) in this case would be about Rs. 1,000. The pay of the two attendants one looking after the bullocks and the other feeding the huller and removing sacks of rice when full, need not exceed 6 annas a day in a country place, and the feed of the 4 bullocks need not cost more than 8 annas a day. The cost of husking in this case, therefore, comes to only about 3 annas per maund of rice turned out, inclusive of interest on capital and wear and tear.

302. We have in discussing the efficiency of Messrs. Burn & Co.'s Mill already given the average cost of husking paddy with *dhenki*. It is possible with the help of expert women to get more work out of *dhenki*. Two parties of such women, one working from 6 to 12 in the morning and the other from 12 to 6 in the evening, can turn out from 4 maunds of paddy an average quantity of either 2½ maunds (more exactly 2 maunds 25 seers) of steamed (*siddha*) rice or 2¼ maunds of unsteamed (*atap*) rice. In obtaining the former an extra woman besides the three at the *dhenki* is required for steaming and drying the paddy and thus keeping the supply at the *dhenki* uninterrupted. Two parties of 4 women at 2 annas a day will cost one

rupee, and the cost of husking thus comes to about 6 annas per maund. In the case of *atap* rice where no steaming has to be done, the cost comes to about 5½ annas per maund under the most favourable conditions. The advantage of having rice husked by the Engelberg Huller is thus obvious.

303. The working parts of the machine being made of chilled steel are extremely substantial. Still the outer coat of the paddy is a very tough substance and no machine can work without undergoing some wear and tear which has been allowed for in the above calculations. The huller-screen (duplicates of which cost only 2 dollars each) is the part of the machine which requires renewing from time to time, say, 4 or 5 times every year. The cylinder also is apt to get worn out, and although the blade-adjusting screw helps to keep the space between the blades on the cylinder and the cylinder-shell properly adjusted, the huller cannot be expected to work when the blades get altogether worn out, which they do in 3 or 4 years. These cannot be renewed in this country and a duplicate huller-cylinder costs in New York 20 dollars. The paddy must be fed in the hopper of the huller in the same condition in which it is considered necessary to feed the mortar of the *dhenki*. In the case of unsteamed paddy, the paddy should be sunned and then spread out for a night in a cool (cemented) floor, before it is husked the next day. The breakage is greater if the paddy is not properly dried in the sun and also if it is in a brittle condition immediately after exposure to the sun in a hot day. In the case of steamed paddy the outturn is nearly 10% more both with the *dhenki* and with the Engelberg Huller. The produce of steamed rice is on the average 68 per cent. and of unsteamed rice 58 per cent. of the paddy used, — a result which is equal to what is obtained with *dhenkies*.

304. The Engelberg Huller Company also supply a gear for man-power to drive Huller No. 3, a shaft being moved round by 12 men and the motion communicated to a pulley

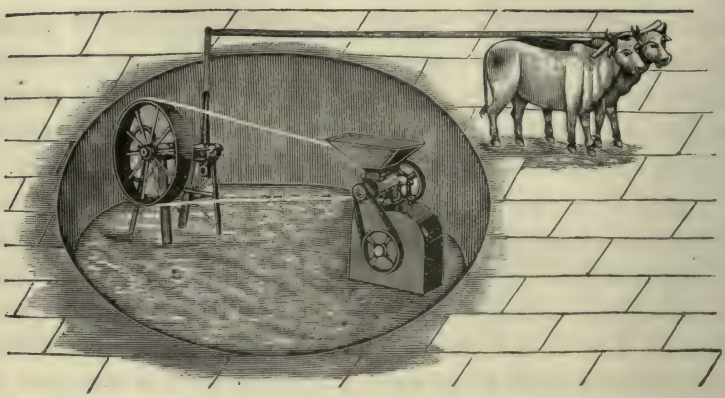


FIG. 56.—ENGELBERG HULLER. (BULLOCK-POWER).

to which the huller is attached by a leather belt. At least 20 Indian coolies would be needed to work this gear, and the cost for husking per maund of rice would thus come to over 8 annas. There would be therefore no advantage in having this gear unless the shaft is adapted for attaching bullocks which can be easily done as shown in the figure (Fig. 56). The price of this man-power at New York is 75 dollars. It is easier to adapt this for bullock-power than the horse-gear already mentioned above. The huller and the pulley or bullock-gear should be both placed in a circular hollow, and the shaft driving the pulley should work above, the bullocks being attached to the end of the shaft and going round and round above the hollow. A railing or a parapet should protect the bullocks from slipping into the hollow through any accident.

305. Huller No. 2, is constructed without the fan or polisher, a separate arrangement being made for a polisher, the rice being conveyed from a series of 10 or 12 hullers to a single polisher placed at the end of the series. For large mills this huller is better adapted than the more complete one represented in (Fig. 55.) where the polisher is enclosed

at the lower portion of each huller. Huller No. 2 not being provided with the polisher costs less (about Rs. 900 instead of Rs. 1,100). The price of a separate polisher capable of cleaning 2,400 to 3,600 lbs. of rice per hour is 300 dollars (about Rs. 1,000). For a large mill Huller No. 2, and a separate polisher for each series of 12 hullers, are the best to have.

306. The winnowing machine supplied by the Engelberg Company is priced 30 dollars, *i. e.*, it would cost about Rs. 125 brought out to India. It is scarcely distinguishable from Dell's Winnower.

CHAPTER XXIV.

WHEAT (TRITICUM SATIVUM).

WHEATS are divided into two main classes, soft and hard. The latter are more glutinous rendering the grain more suitable for making semolina (*suji*), while the soft starchy grains are especially suitable for the production of fine flour or *maidá*. Wheats are also divided according to the colour of the grain into white and red. The following races or strains of wheat are recognised in Bengal :—

(1) *Dudhiá* wheat especially suitable for making fine flour ; grain,—white, soft, plump and rounded ; leaves,—usually broader than those of other varieties.

(2) *Jámáli* wheat,—grain fairly large, soft, pale-red ; leaves,—narrow.

(3) *Gangájali* wheat,—grain,—pale-grey, large, hard, elongated, with somewhat angular outline, difficult to break or bite. Best adapted for making *suji* and *atta*. Leaves,—broad.

(4) *Kheri* wheat,—hard, pale-grey grains of medium size; leaves,—narrow.

(5) *Piusa* wheat, -grain,—soft, pale-grey, very small; leaves,—narrow.

(6) *Nanbia* wheat,—grain,—hard, reddish, very small; leaves,—narrow.

308. A variety of the *Jamali* wheat (soft red wheat) is called *Maghia* as it ripens very early, in Magh or Falgun (about February). A bald or beardless variety of dark brown but soft grained wheat grown in Singbhum is locally known as Ghyo-changmed. All the other Bengal wheats are more or less bearded.

309. Better classes of wheat are however grown in the C. P., the Punjab and the N.-W. P. of India. In the C. P. and Southern India the best hard wheats are grown, while the best soft wheats are grown in Northern India, in the basins of the Ganges and the Indus and their tributaries. In Southern India, in the moist parts of the Gangetic Delta, in Orissa and in Burmah, poor hard red wheats are grown and a tendency has been noticed for high class wheats degenerating in these regions. In the extreme south of the Madras Presidency and in Mysore the wheat is of the spelt (Triticum speltum) variety, in which the husk adheres strongly to the grain as in rice, and it is husked in the same way as paddy. The N.-W. P., Oudh, C. P. and Behar soft white wheats realise higher values than any others. Some of the Australian and Russian wheats are the best, and the experiments which are being conducted in the Nagpur Experimental Farm, with Australian, hybrid and rust-resisting wheats are some of the most important experiments going on in India. The relative value of Indian,

English and some other high class wheats can be judged from the following figures.

	Wt. of 100 separate grains.	Impurities.	Percentage of gluten by water test.	Yield of flour.
	grns adops.			
1. Soft white Indian wheat ...	55·4	1·52%	6·6	75%
2. Soft red Indian wheat ...	51·8	0·72 „	9·9	76 „
3. Hard white Indian wheat. ...	68·3	3·7 „	12·1	77 „
4. Hard red Indian wheat ...	77·7	1·2 „	13·2	76 „
5. English wheat ...	57·4	1·5 „	11·0	69 „
6. Australian wheat ...	80·5	1·0 „	11·9	72 „
7. Russian (Saxons ka) wheat ...	37·3	0·9 „	22 6	72 „

From the above table it would seem that Indian wheat compares very favourably with other wheats, and it is superseded only by the finest Russian and Australian varieties. The Indian wheat is also remarkably free from excess of moisture and is therefore well adapted for mixing with English wheats which are too moist. The thinness of skin of Indian wheats and the consequent largeness of yield must always place them in the front rank as millers' wheat whenever they are handled with intelligence. Indeed Indian wheats are getting well known in the English market and their value is now equal to that of some of the best European and American wheats. The hard white Indian wheat

which in England fetches 4*s*. to 5*s*. a quarter less than soft white wheat, commands an extensive and ready market in Southern Europe for the macaroni-making industry.

310. The names of the Indian wheats which are prized as equal to any in the world are :—(1) *Gundun Safed* of Delhi, (2) *Daudi* of *Unao* in Oudh, (3) *Saman* of Bulandshahr and Meerut in the N.-W. P. (4) *Safed* of Dera Ismail Khan in the Punjab, and (5) White *Pissi* of the C. P. and (6) Buxar No. 1 Club wheat. They fetch 46 to 48*s*. per quarter of 496 lbs. in the English market. The weight per bushel of Indian wheat varies from 60 to 65 lbs. while the recognised weight of a bushel of English wheat is 60½ lbs.. Calcutta wheat is burdened with refraction of 5 per cent. and Bombay wheat of 4 per cent. in the English market, which only induces cultivators or *mahajans* to mix earth or other foreign matter with the wheat. In post-monsoon consignments the impurities in Indian wheat are chiefly due to weevils. The price of wheat in India depends on local conditions, and not on the price ruling in England.

311. India is, nex tto the United States, the largest wheat producing country in the world, and the significance of this fact is very great when we consider England's relation with India, as England depends mainly on imported wheat and India is supplying more and more of this. The production of wheat in the provinces under direct British rule has been estimated at 30,000,000 to 35,000,000 quarters, *i. e.,* about the same quantity as is produced by Russia or France. Great Britain and Ireland produce only 10,000,000 to 13,000,000 quarters per annum.

312. The area under wheat in Bengal is estimated at 1,472,000 acres *i. e*, 2·28 per cent. of the total cultivated area of the Province. It is only in the district of Murshidabad that more than 10 per cent. of the cultivated area is cropped with wheat. It shows the prosperous condition of this dis-

trict, due chiefly to its political and industrial position at one time in Bengal, which it has not altogether lost as yet. In Rajshahi also wheat is recognised as an important crop, Rajshahi sharing with Murshidabad the same social and industrial position. The richer classes particularly of Bihar consume wheat bread very largely. With two exceptions, the districts of the Patna and Bhagalpur Divisions may be regarded as the wheat-growing districts of Bengal. The following districts have each more than 50,000 acres under this crop.

District.	Acreage.	Percentage of cultivated area.
Bhagalpur	192,200	6·95
Saran	140,000	7·69
Gaya	126,800	5·81
Murshidabad ...	122,300	10·37
Shahabad	115,500	6·36
Monghyr	106,600	3·99
Darbhanga	102,000	4·31
Patna	100,100	8.56
Rajshahi	75,400	6·33
Muzaffarpur ...	70,000	3·11
Sonthal Pergunnas ...	66,400	3·66

313. *Soil.*—Clay-loam, easy of irrigation, situated in a dry locality, is the best soil to choose for wheat. Sandy loams are also utilised for growing wheat, especially *dearh* or new alluvial lands, where mixtures of wheat and barley or wheat and mustard or linseed are commonly taken. The best crops of wheat are grown on lands newly brought under canal irrigation. Where canal water is used for irrigation for a number of years the outturn is found to fall off even below the original level. This is due (1) to excessive use of water for irrigation which washes away valuable food particles and brings up to the soil undesirable soluble salts and (2)

to exhaustion caused by taking of heavy crops at first without manure.

314. *Cultivation.*—Shortly, the land is to be ploughed and cross-ploughed, first with country plough or Sibpur plough and then with grubber as often as convenient, and operations commenced as soon after the rains are over as possible. When by ploughing, cross-ploughing, grubbing, harrowing and rolling land has been prepared, all the operations following close one upon another that there may be no undue loss of moisture, seed should be sown by drilling. Deep cultivation is advisable for the wheat crop, hence grubbing is recommended. Sowing should be done after cold weather properly sets in *i. e.*, somewhat later than when barley, and other *rabi* crops are sown. Beginning of November is ordinarily the best time for Lower Bengal. In rocky and laterite soils sowing should be done earlier, say about the 20th or 25th October, or earlier still if the rains cease early in October. About 100 lbs. of seed are used per acre, but this is too much. 50 lbs. are quite enough. After sowing, the field should be divided out into irrigation-beds by scraping up little banks of earth with a wooden shovel which are usually worked by two boys in the N.-W. P. and Oudh. This wooden shovel may very well be introduced into practice in Bengal for making irrigation-beds. If the soil is too dry it should be irrigated before sowing. Three or four irrigations altogether are ample for dry localities; but one or two irrigations should be always done, though in moist tracts irrigation may be altogether dispensed with for the wheat and barley crops. Where the natural climatic conditions in any season are exceptionally favourable no irrigation may be required. The land may be moist at sowing season, and in December and January there may be two or three fairly heavy showers of rain. One hand-weeding should be done within a week or ten days after the first watering. Two hoeings with the American wheel-hoe may be given afterwards to promote the growth of the crop.

315. *Manure.*—Saltpetre 1½ maunds per acre (top-dressed), is the best manure for wheat. If the land is known to be poor, 1½ maunds of bonemeal should be used beforehand at the time of ploughing, though no immediate benefit will be derived from such application. 5 maunds of oil-cake may be used instead. But better immediate effect will be obtained from the saltpetre. No manure is required for *dearh* land which is annually renovated with silt.

316. *Rotation.*—Juar or other millets and wheat are commonly grown in rotation though both are grain-crops. *Juar* and barley being surface feeders may be grown together or successively with wheat which is a deep rooted crop. But better result would be obtained from Kurthi or Bhadoi Mung or Bhadoi Kalai being grown before wheat. Lentils or grain grown along with wheat is theoretically speaking not a bad practice as the leguminous crop supports the wheat-crop and prevents exhaustion of soil ; but mixed crops are found to be undesirable for more than one reason.

317. *Harvest.*—Wheat harvest should be commenced after the grains are quite ripe and the straw quite dry and crisp.

318. *Outturn.*—9 or 10 maunds per acre is about the average yield of grain, and 10 to 12 maunds of straw.

	Rs.	as.	p.
Cost.—1 Ploughing	0	12	0
1 Cross-ploughing followed by laddering ...	0	12	0
1 Bakharing	0	6	0
1 Cross-bakharing	0	6	0
1 Grubbing	0	6	0
1 Cross-grubbing	0	6	0
1 Harrowing	0	4	0
1 Rolling	0	4	0
1 Drilling*	1	0	0

* Cost of drilling seed with the help of an American wheel-hoe (1 tine only being used) comes to nearly Re. 1 per acre. But with a proper seed-drill the cost would come to only about 6 annas per acre or less.

Cost of 50lbs. of seed @ Rs. 3 per maund ...	2	0	0
Cost of pickling	0	8	0
1 Rolling after sowing	0	4	0
1½ Maunds of saltpetre	6	0	0
Watering with saltpetre solution	1	8	0
1 Regular irrigation	1	8	0
1 Hand-weeding	2	8	0
2 Wheel-hoeings	1	2	0
Reaping	1	2	0
Threshing and winnowing with machine ...	3	0	0
Rent (half year's rent)	1	8	0
Depreciation on implements	0	8	0
Total cost—	26	0	0
Produce,—12 maunds of grain @ 3 rs. ...	36	0	0
and straw 16 maunds	0	8	0
Total outturn—	37	8	0

Net profit per acre, about Rs. 11.

319. The points that should be borne in mind in extending the cultivation of wheat in any part of India are:—(1) the seed should be of the best soft white variety; (2) a rust resisting variety (from the Nagpur Experimental Farm, for instance) should be chosen; (3) the soil should be deeply cultivated, as deeper cultivation is required for wheat than for rice, barley and oats; (4) saltpetre should be used for top-dressing; (5) It should not be sown mixed with other crops and the seed used should be unmixed and select and the thrashing should be as clean as possible; (6) sowing should not be done until cold weather fairly sets in, barley and oats being sown earlier in the season; (7) if there is not sufficient moisture at the time, land should be irrigated and *bakhared* afterwards before sowing; (8) wheat should be twice irrigated, if possible, and the sites chosen for wheat land should therefore be close to water. (9) Harvesting should be done after the grain is thoroughly ripe. (10) Grain should be stored so that there may be complete protection against

weevils. Paddy and oats are not so subject to the attack of weevils as wheat and cultivators often find their wheat seed completely destroyed by weevils at sowing time and their sowing of wheat seed results always in more or less partial germination. (11) Wheat seed should be sown after pickling, to avoid rust, insect pests and damage by birds.

320. The subject of storing of grains against weevils and on pickling will be discussed in the Part devoted to Insect and Fungus Pests.

CHAPTER XXV.

BARLEY (HORDEUM HEXASTICHUM).

BARLEY like wheat is one of the most ancient of cultivated crops, but the two-rowed barley (H. distichum) alone has been discovered in the wild state in several parts of Central Asia, while wheat has not been so discovered. The six-rowed barley (H. hexastichum) or bigg, which is the staple of Indian cultivation, has not been discovered in the wild state, though this is the variety which was cultivated in Europe, Asia and Africa, in very old times. The four-rowed barley (H. vulgare) is the staple of European cultivation. Probably the four-rowed and six-rowed barley are derived from the wild two-rowed variety. Indian barley is richer in albuminoids than English barley. The composition of the former is :—

Starch	63 per cent.
Cellulose	7 „
Oil	1 „
Albuminoids	11·5 „
Ash	3 „
Water	12·5 „

322. A white huskless barley has been grown with success at the Cawnpore Experimental Farm and it is worth while repeating this experiment.

323. *Cultivation.*—Barley is grown to a small extent all over India and chiefly in the N.-W. Provinces of India, either by itself, or mixed with wheat, or gram, or with peas, or lentils. The most favourite mixture is barley and gram. Barley and wheat as a mixture is not so popular, but barley as surface feeder and wheat as a sub-soil feeder, may be grown together in rich soils. Rape (Brassica Campestris), mustard (Br. Juncea), tárámani or tirámirá (Eruca sativa), and linseed are also grown along with barley. Lighter soil is preferred for barley than for wheat. The land is prepared, and the seed sown a little earlier in the season than wheat, unless they are sown together. About 100 lbs. of seed are used per acre. A little more seed is required for barley than for wheat, but 100 lbs. per acre is too liberal an allowance. Seed properly stored and protected against weevils germinate properly and smaller quantities of such seed are sufficient. 60 to 70 lbs. of barley should be ample to sow an acre. Barley is a hardier crop than wheat and it does not require the same amount of weeding and irrigation and it is not so subject to rust. One hoeing with the American (Planet Jr.) wheel-hoe and one watering with a mixture of 1 maund of saltpetre and 20 maunds of water per acre may be applied with great advantage when the plants are above 6 ft. high. The harvesting should be done earlier than wheat *i. e.*, before the grains are very ripe. The cut sheaves may be made to stand with ears upwards, near the thrashing floor and when the grains are quite dry they can be threshed or flailed out.

Cost.—1 Ploughing and cross-ploughing	...	1	8 0
1 Bakharing and 1 cross-bakharing	...	0	12 0
Seed (60 lbs.)	...	1	8 0
Pickling the same ...	...	0	4 0
Cost of sowing in drills ...	...	1	0 0

Reaping	1	8	0
Threshing and winnowing	3	0	0
Irrigation, if necessary	1	8	0
Manure, 1 mnd. of saltpetre	4	0	0
Applying the same with water ...	1	8	0
Rent (half charged against this crop) ...	1	8	0
Depreciation, &c.	0	8	0
	18	8	0

Outturn.—12 mnds. of grain at 2rs. and 16 mnds. of straw at 1 anna 25 0 0

Net profit per acre, about 6 8 0

324. Barley grain, parched and mixed with gram, is given to animals as food. Barley meal, prepared after parching, is eaten largely by up-country men and is given to animals also. Barley straw is not a safe straw to give to horses and cattle as it is liable to cause colic, being bearded and spiney. It may be used for litter with great advantage. Barley leaving little crop-residue and being a surface feeder, is a greater exhauster of surface-soil than wheat or rice. For this reason this crop should be either sparingly grown, or only the ears should be harvested and the straw plouged in.

CHAPTER XXVI.

OATS (AVENA SATIVA).

IT is a very minor crop in India, especially in Bengal. Like wheat and barley, oats may be grown on lands suitable for *Aus* paddy after the *Aus* paddy has been harvested. It can be also grown well on *Dearh* lands and lowlying lands which are dry by October and November. In fact, oats can

be grown on all kinds of soil, light and heavy, rocky and calcareous, the best result of course being obtained from rich friable loam, somewhat lighter than typical wheat land. The range of temperature at which oats grow properly is greater than in the case of wheat or rice.

326. As soon as the rains have stopped in September or October, the land should be ploughed and cross-ploughed and *bakhared*, then harrowed and rolled before drilling. Rotten cowdung, 150 maunds per acre, applied on the land at the time of cultivation and ½ maund or 30 seers of saltpetre top-dressed when the seedlings are about 6 feet high, give the best result. 50 lbs. of seed (which is lighter than wheat seed) is ample per acre. After drilling the seed, a light wooden roller should be passed to bury the seed and give compactness to the soil. Seed should be pickled as usual before sowing. One watering at the time of applying the saltpetre in solution is necessary. If the crop looks vigorous and if the land is not very harsh and dry no other watering will be required. One hand-hoeing and one wheel-hoeing with the Planet Jr. American hoe, should be sufficient.

327. The harvesting of oats requires special care, as it should be done when the grains are not fully ripe and the straw is still somewhat green. Harvested late, the grains shed and the straw loses in feeding value. Oat-straw is more nutritious than rice or wheat straw. An acre should yield 20 maunds of grain and 30 maunds of straw cultivated as above.

Oats are sometimes grown by irrigation to supply green fodder *e. g.*, at the Hissar Government Cattle Farm, where three cuttings of the green fodder are taken, and the fourth cutting left to bear a thin crop of grain.

CHAPTER XXVII.

INDIAN CORN (ZEA MAYS).

THE area under maize in Bengal is about 2 401,400 acres, *i.e.*, 3 17 per cent. of the total cultivated area of the Province. In all the districts of the Patna Division, in Monghyr, Bhagalpur. Sonthal Parganas, Hazaribagh, Singhbhum and Darjeeling, maize forms a principal article of diet among the poor. The districts which have from about 5 per cent. to 15 per cent. of their cultivated area under this crop are :—

	Acres.	Percentage of cultivated area.
Monghyr ...	397,000	14·87
Saran	253,500	13·92
Bhagalpur ...	242,600	8·77
Hazaribagh ...	217,200	10·08
Champaran ...	169,000	8·38
Sonthal Parganas ...	162,500	8·96
Darbhanga ...	143,900	6·07
Muzaffarpur ...	110,000	4 88
Patna	108,600	9·29
Darjeeling ...	22,200	8·78
Singbhum ...	11,300	10·08

329. This plant has not been discovered in the wild state. In remote antiquity it was not known in the Old World, but grown only by the Peruvians and the Mexicans. It has been however found suitable for nearly every climate and it is now grown successfully in the cold hills of Sikkim and Bhutan as well as in the hot and arid soil of Manbhum and Singbhum. It does well in the moist climate of Bengal and in the dry climate of the N.-W. Provinces, Rajputana and the Punjab. The American varieties are the

best, but these introduced into India degenerate into the local Indian types in the course of a few generations. Improvement on the lines of cultivating the best Indian maizes only, seems to be the most practical way of dealing with the question. Originally maize must have come from America to India, but there are now regular Indian types. The three recognised Indian classes are: (1) large-cobbed dry grain producing class, usually yellow; (2) the class that produces sweet and large green cobbs, usually white, for roasting or boiling purposes, and (3) the class that gives the best pop-corn which is usually a many, but small-cobbed, class. The first is rich in starch and the second in glucose. White, yellow, red and black varieties are also distinguished, and then there is the further distinction between *kharif* and *rabi* maize, also between those which take only 2 or 3 months growing and those which take as many as six. The stalks of maize being very tough and free from siliceous matter, is used in Germany for making high class paper. Bank-notes are made from maize-stalk pulp. Attempt may be made to grow maize largely in the vicinity of Indian paper mills and induce the paper manufacturers to use maize stalks.

330. Maize grain, both green and dry, cooked and uncooked, is somewhat difficult to digest. But made into meal and cooked, it is easily digested. Cornflour is manufactured by first steeping the maize in hot water and then grinding it between large millstones. The pulp is then passed through sieves into huge vats where the corn flour settles, the gluten remaining in the sieves. Maize diet gives the tendency to accumulate internal fat which is injurious to working animals like bullocks and horses. If cattle are fed with maize it should be given mixed with other food, such as straw, grass and oil-cake. It should not be used at all in the hot weather. Too much maize produces acute indigestion, colic, impaction of the rumen, swelled legs, &c. But climate and habit have a great deal to do with the question of diet. Bhutia ponies

and Sonthal coolies are able to digest maize even outside their own native climate. Maize contains more fat and is more fattening than other grains if it can be digested. The cobbs divested of grains are rich in carbonate of potash, containing as much as 1·762 per cent., *i.e.*, twice as much as is contained in wood, and they should, therefore, be stored in the manure pit. The straw is not of much value as fodder (except for elephants) if the cobbs are allowed to ripen ; but if the cobbs are disposed of in the green state, maize-stalks are as valuable for fodder as juar stalks.

331. Maize is an exhausting crop and it requires *heavy manuring* or very good soil to produce good yield. Carrots are frequently sown in the N.-W. Provinces between the lines of *rabi* maize, while the crop is still standing, especially when drought is threatened. The leaves of the carrots are given to cattle and the roots are eaten by people. In years of heavy rainfall, gram, poppy, mustard or safflower follows maize. But wheat or barley is often grown after maize, though it is against the principle of rotation of crops to do so. In some parts of the Punjab three crops are taken in succession in the same year from the same land. Melon is grown after wheat or barley is off the ground in March, and the land is prepared early in July for the maize crop as by then the melon crop is over. Melons as a catch-crop are also largely taken in Bengal in seasons of drought, immediately after a bad *rabi* harvest.

332. *Soil.*—Maize prefers high open and even rough gritty soil, with plenty of humus in it. The hilly regions of the Darjeeling district are especially suited for growing high class maizes. In Lohardaga, Singbhum, Manbhum and in Behar districts also, large crops of maize are obtained. The damp alluvial low-lands of Bengal are not so suited for this crop especially if it is intended for grain. But homesteads, throughout Bengal, where no waterlogging takes place, are well adapted for growing maize for green cobbs.

Maize may be grown either as a *kharif* or a *rabi* crop, but it is not profitable to grow it as a *rabi* crop unless there are special facilities for irrigation.

333. *Cultivation.*—In May or June after a good shower of rain, land already ploughed up once in the cold weather, should be ploughed and cross-p loughed and harrowed and the seed should be dibbled 1½ to 2″ deep in regular lines of 18″ × 18″ at the rate of 3 to 4 seers per acre. When the plants are all well up, one hand-weeding should be given. If the soil is found too dry 3 days after sowing and no rain is immediately expected, it is safe to irrigate the land once. Early sowing with irrigation (if necessary) gives much better result than late sowing when no irrigation is required owing to the monsoon being in full swing. Heavy rain does the greatest harm to maize plants when they are yet of small size. No harm is done to maize plants by heavy rains if they come after they are 9″ to 18″ high. If irrigation is easy, it is better to sow the seed in April or May after irrigation, as the drought subsequent to a free germination, is not so injurious to maize plants which are deep rooted plants, and irrigation may be resorted to if there is prolonged drought. After one hand-weeding two hoeings with the Planet Jr. hoe would give the plants a very good start. The use of saltpetre would be of further benefit. If the land is known to be poor, cowdung or some other general manure applied in the cold weather or before sowing would give better result. Continuous rainfall is not helpful to the growth of maize. There should be periods of fair weather intervening between heavy showers of rain. Before the rains set in earthing should be done that there may be no waterlogging at the base of the plants.

334. *Outturn.*—It is more profitable to sell the green cobbs and use the stalks for fodder than to let the grain ripen. The cobbs can be picked and sold in June, July and August. If they are allowed to mature, harvesting should be done in September or when the grains are quite ripe and dry.

5 to 8 mds. of grain per acre is considered a fair yield but 30 or 40 mds. are sometimes obtained. The value of a 5 to 8-mnd. crop is only about Rs. 10. An acre (if ravages of jackals are prevented) may produce 20,000 green cobbs. If these are sold at an average price of 8 cobbs. per pice, the produce of 1 acre may come up to Rs. 35 to Rs. 40. In fact, about Rs. 40 were realised in 1898 from the maize crop at the Sibpur farm, out of $\frac{9}{10}$ths of an acre only, divided into nine equal plots. There were, moreover, only 3 plots of maize grown singly, the other 6 plots containing a mixture of maize and arahar, or maize and cotton, and the maize in these 6 plots was known to have done badly, partly on account of late sowing and partly on account of the mixture. Maize is a profitable crop to grow near large towns, where there is a ready market for the green cobbs. The precaution of watching the crop day and night, not only against jackals but also against crows and other birds, squirrels, rats, and in some parts of the country, against pigs, monkeys and porcupines, is most essential.

335. It is convenient to use a maize-huller (Fig. 51) for detaching the grains from the cobb. By flailing or beating with sticks, the operation is done rather imperfectly.

CHAPTER XXVIII.

JUAR (SORGHUM VULGARE).

THIS crop, though of minor importance in Bengal, is the staple grain crop of Southern India. Three varieties of sorghum should be recognized as of special merit: (1) sugar sorghum (sorghum saccharatum) which yields several cuttings of sweet and palatable fodder; (2) the Gahamá or Karmi sorghum (Sorghum Roxburghi) which yields the heaviest crops of fodder, and (3) the Deo-dhan sorghum, the Cholam of Southern India (Sorghum vulgare), which yields

the best grain, inferior only to the best wheat for bread-making. The first is also known as Sorgho or Imphe and is grown in America and Africa. Sorghum halipense grows wild in India, and the cultivated varieties may have originated from this.

337. *Chemistry :*—The high value possessed by Sorghum grain will be evident from the following table :—

	Albuminoids.	Starch.	Oil.
Indian Sorghum ...	9·3 %	72·3 %	2 %
Indian Rice ...	7·3 „	78·3 „	·6
Indian Wheat ...	13·5 „	68·4 „	1·2 „
Indian Oats ...	10·1 „	56·0 „	2·3 „

The following figures show the high value of green juar as fodder compared to turnips which are greatly prized as fodder in England :—

	Green Juar.	Turnips.
Water ...	... 85·17	90·43
Albuminoids ...	... 2·55	1·04
Starch and fat	... 11·14	7·89
Ash ...	... 1·14	·64

338. To the agricultural population, juar is a more important crop than even wheat and rice. It yields a nourishing grain about the same quantity per acre as wheat or rice (900 lbs.) and ten times as much in fuel and fodder as the ordinary cereal crops. As fodder crops are at a discount in India, the growing of superior varieties of juar for food and fodder should be encouraged as much as possible. When grain is allowed to ripen the lower half of the juar stalk should be used for fuel and the upper half for fodder. But the best fodder is obtained from green juar before the heads appear when it is in full vigour of growth and not too tall. Cut at this stage it affords a more nutritious fodder, than even turnips which are so highly valued in England, and a second and a third cutting, and sometimes even a fourth, may be also obtained if the land is cultivated after each cutting. The

second cutting is of less value and the third cutting of still less nutrient value, but these are obtained at the dry season when there is great scarcity of fodder.

339. *Juar for fodder* should be sown with the help of irrigation, if necessary, in May, and sowings should continue through June and July, that there may be a succession of fodder crops of first, second and third cuttings from July to March or April, a portion of which can be dried and preserved for use from April to June. The dry stalks should be stacked and thatched. About 280 maunds per acre, *i.e.*, about 22,000 lbs. is the average weight of the first cutting and the second and third cuttings if irrigated, produce as much again, or if left unirrigated but cultivated in proper season, about 10,000 lbs. more. Dried, the fodder loses about two-thirds in weight. If the first cutting is taken when the rainy season is still on, and the second cutting when the land is still moist, say early in November, and if the land is ploughed both times, very fair result can be had even without irrigation. 30,000 lbs. to 40,000 lbs. of green fodder will keep a yoke of oxen receiving 60 lbs. per diem, for one year. Any of the juar that is allowed to run into grain will also afford about 1,000 lbs. of dry stuff per acre, half of which can be used as fuel and half as fodder, but this fodder is less valuable than green juar (dried). Juar straw is at least as good as rice straw and it should be given at the rate of ½ a maund per bullock, properly chopped up and mixed with oil-cake and water. If 500 lbs. of grain and 10,000 lbs. of straw are obtained per acre of juar, an acre will support a man and a bullock, the man being allowed 40 lbs. of grain per month.

Soil :—Juar is grown both on rich and on poor soil and though it does best on deeply cultivated rich loam (like the black cotton soil of Southern India), it is a very hardy crop and it stands drought well, though it is not a deep rooted crop like maize, and poor soils are usually chosen for growing it. Indeed if rich land is chosen for this crop the yield

of grain is proportionately very small, the straw only showing a most luxuriant growth. Lowlying land is unsuitable for juar as water-logging kills it.

340. *Cultivation.*—The same sort of cultivation as is recommended for maize should be adoped. The roots are easily spoilt by water-logging, hence ridging or earthing is advisable and water accumulating in the field should be let out. 10 lbs. of seed should be used per acre, if it is grown for grain, but 30 lbs. per acre if it is grown for fodder, sowing being done 18″ × 9″ apart in the former case and 9″ × 6″ in the latter. It is usually grown mixed with *arahar,* cotton &c. But the best result is obtained by growing it singly.

341. The juar crop is very much subject to fungoid diseases specially if the heads appear in the rainy season. Rust, smut and bunt having been all noticed. Insects, birds and squirrels also do a great deal of damage. We have seen smut in a very exaggerated form in the juar grown at the Sibpur farm. The seed should always be sown pickled with sulphate of copper for preventing fungoid diseases.

342. It should be noted here, that stunted juar grown when there is deficiency of rainfall, is poisonous to cattle, containing probably an excess of saltpetre. If irrigation is not available juar should not be sown till June *i. e.*, the commencement of monsoon, that the ill effect of early drought on this crop may be avoided. Sowing late in August should not be done either, that the ill effects of late drought may be also avoided. Death among cattle from eating stunted and parched up sorghum is fairly common in the Punjab. Veterinary Surgeon Anderson discovered on breaking open a stalk of stunted juar plants which had killed cattle, a very considerable quantity of a white salt deposited in crystals in the pith more especially at the nodes. This was found to be nitrate of potash and the quantity in the stunted and withered stems was so large (25 per cent. of the dry matter), that this was at once put down as the determining cause of death.

CHAPTER XXIX.

MARUA (ELEUSINE CORACANA).

THIS millet is more commonly grown in Bengal than sorghum, though its yield is rather poor, the average being about 8 maunds per acre. In some parts of Madras it produces over 2,000 lbs. per acre in the red soils, with irrigation. At the summit of each stem are 4 cruciform digitate spikes full of grain. This grain is supposed never to be attacked by insects and to keep for any length of time. There is some advantage therefore in growing this grain for storing it against years of famine whenever that may happen. The straw is said to decrease the flow of milk. 4000 lbs. of straw per acre is obtained in some irrigated soils in the Madras Presidency.

344. *Cultivation.*—Immediately after wheat or some other *rabi* crop is harvested, the land is prepared in the same manner as it is prepared for *Aus* paddy. The seed (7 to 10 lbs. per acre) is sown broadcast, and a log of wood or roller is passed over the land to cover the seed. When the plants are 2″ or 3″ high, harrowing is done, and vacant spots are filled in by plants taken out from those spots where they are too thick. In the Punjab and in Mysore the seed is sown in seed-beds and afterwards transplanted. This is a better system. The harvesting is done in September *i. e.*, about 3 months after sowing. It is a difficult crop to harvest as the ears ripen very irregularly. The expense of cultivation nearly always comes up to the value of the crop. The proportion between the quantity of seed sown and the out-turn of grain is about 1 : 40. The straw is more nutritious than rice-straw though it is said to decrease the flow of milk. The quantity of straw ordinarily obtained per acre is less than

1000 lbs. The grain contains very little husk, only about 5 per cent. The chemical composition of the husked grain is given below :—

Water	13·2 %
Albuminoids	7·3 „
Starch	73·2 „
Oil	1·5 „
Fibre	2·5 „
Ash	2·3 „
Nutrient ratio	1·13 „
Nutrient value	84 „

345. The grain is somewhat indigestible and is eaten only by the poor classes. The hill tribes of Bengal make a beverage out of this grain which is imbibed even by the upper classes of natives.

346. The area cultivated for this millet in Bengal is estimated at 963,500 acres or 1·49 per cent. of the total cultivated area of the province. In the following districts the cultivation of this crop is of some importance :—

	acres	Percentage of cultivated area.
Darbhanga	230,000	9·71
Bhagalpur	123,100	4·45
Hazaribagh	105,100	4·88
Saran	81,400	4·47
Gaya	77,000	3·53
Patna	71,500	6·11
Singhbhum	61,000	4·88
Monghyr	42,900	1·68
Sonthal Parganas ...	30,100	1·66
Puri	23,000	2·87
Palamau	9,300	1·87
Darjiling	5,300	2·09

347. *Other millets.*—With regard to the other less important cereals, a table may be given summarising the principal facts regarding their cultivation :—

	Time of sowing.	Quantity sown per acre	Time of harvesting.	Outturn of grain	Remarks.
1 Panicum miliaceum,—common millet or *cheena.*	February & March or August	10lbs.	May or October	600lbs. of grain +1000lbs of straw	Grown by irrigation. Digestible & cooked like rice; grown also for fodder only, in the Punjab. Seed shed easily. *Paramanna* made out of it is delicious.
2. P. Frumentaceum or *shyama.*	End of June.	2 lbs.	October	400 lbs. of grain +800lbs. of straw	Rough jungle land is chosen. Considered a poor grain. No manuring or irrigation. Good fodder.
3. P. miliare, or *gondli.*	June & July	10lbs.	Octr. & Novr.	500+1000 lbs.	Dry & sandy localities chosen.
4. P. Psilopodeum,—*Menjhri* or *Kutki.*	End of June.	2lbs.	October	600 lbs. (grain)	Grain husked like paddy and eaten like boiled rice.
5. P.Italicum,—*Káon* and *Shyálnaja.*	June and July.	5lbs.	Octr & Novr.	500+1000 lbs.	Dry, sandy soil.
6 Pennistium typhoideum or spiked millet (*bajra*).	End of July.	6 to 10lbs.	Octr. & Novr.	300 to 500 +1000lbs	Poor, free, dry, sandy soil. Village refuse sometimes used as manure. No irrigation required: Considered poor food & poorer fodder. Pollen grain washed away if sowing is done earlier.
7. Paspalum Scrobiculatum or *kodo.*	End of June.	2 lbs.	October	600 lbs.	Jungle land and rough rocky soil chosen. No manuring or irrigation done. Straw said to be poisonous. Grain has intoxicating property.

CHAPTER XXX.

BUCK-WHEAT (POLYGONUM PHAGOPYRUM).

THOUGH not a graminaceous crop, buck wheat is classed among cereals, as bread is made out of the flour from this grain. Its straw is more nutritious than cereal straw. It is grown in the Darjiling hills, where it is called *Pháphar*, also in Bihar and in the Central Provinces, where it is known as *Rájgir*. It is sown at the end of June on roughly prepared land at the rate of 50 lbs. per acre when broadcasted or 12 to 25 lbs. when drilled. Harvesting is done in October. The seed sheds easily when it is ripe and it is therefore necessary to get on with the harvesting operation early. Harvested early, the straw also is more nutritious. The green leaves are cooked and eaten as *Ság*. 1200 lbs. of grain may be taken as the average produce per acre on suitable soils. Clay soil is not suitable for this crop, and it is very curious it grows best on poor granitic soils and it is scarcely ever manured. The grain of buck-wheat is very nourishing. A bushel of buck-wheat weighs about 50 lbs. and a bushel of oats about 40 lbs. One bushel of buck-wheat is considered equal to two of oats in feeding value. 8 lbs. of buck-wheat flour is equal to 12 lbs. of barley meal. For feeding hens buck-wheat is specially appropriate, as it induces them to lay eggs earlier. Another advantage of growing buck-wheat consists in the fact of its getting ready in 10 weeks after sowing, and it is therefore a splendid catch-crop. Its suitability for growing on poor soils is further enhanced by the fact of its being able to stand greater extremes of cold and heat than most crops. Hence it is suitable for growing both in the Darjiling hills and in the archæn soils of the Chhota Nagpur Division which are poor even in lime. It is killed by frost, but it can stand a temperature of 105° to 110° F.

CHAPTER XXXI.

PULSES.

NEXT to cereals, pulses occupy the most important place as food-grains, though oil-seeds and jute occupy more land in Bengal. Pulses are included under "other food grains" in Government returns, but it has been estimated that the total area under pulse-crops in India is about 48,000,000 acres, *i.e.*, about 15,000,000 acres more than the area occupied by wheat. The export of gram which is fairly constant amounts to only about 315,000 cwt. valued at about 10 lakhs of rupees, and of other pulses put together about 632,000 cwt. valued at 18 lakhs of Rupees. The principal pulses of India are according to their relative importance :—

(1) Cajanus Indicus, pigeon-pea, *dál*, or *arahar*.
(2) Cicer arietinum, chicken-pea, gram, *chholá* or *chená*.
(3) Dolichos biflorous, the horse-gram, *Kurthi kalai* or *Kulthi*.
(4) Pisum arvense, field-pea, *desi matar*.
(5) P. Sativum, European and American pea, *Bilati matar*.
(6) Dolichos lablab vulgare, Indian bean, *Shim, popat*.
(7) Glycine hispida, the Soya bean, *bhát* or *Gari-kalái*.
(8) Lathyrus Sativus, *Kheshari*, *tur* or *tewra*.
(9) Ervum Lens Esculenta, the lentil, *musuri*.
(10) Phaseolus aconitifolius, *moth*, *mothi* or *bhringi*.
(11) P. Mungo, var. glabar, green gram, *mung* or *mug*.
(12) P. Mungo, var. radiatus, *Másh-kalái* or *Urd*.
(13) P. Vulgaris, Kidney-bean, French-bean, or haricot.
(14) Vigna Catiang, Cowgram, *barbati*.
(15) Cyamopsis, psoralioides arhariá shim.

350. The general recuperative effect of pulse crops on soils should be remembered. Lime and ashes are the best manure for pulse crops, and cowdung and other organic

manures, the worst. Land full of leguminous weeds should be considered rich land. The commonest leguminous weeds of Sibpur, which are also excellent fodder for milch cattle, are *Páyrá matar* (Pisum quadratum), *Chuná kalái* or *Ankrá* (Vicia sativa) and *Chuná masuri* or *Ankri* (Vicia hirsuta). The following table summarises the principal facts regarding the cultivation of pulse crops.

Name of crop.	Time of sowing.	Quantity sown per acre.	Time of harvesting	Quantity harvested per acre.	Remarks.
1. (1) Arahar Maghy & (2) Chaitali.	May, End of June (C. P.), up to July (Madras.)	5 to 10 lbs.	(1) January (2) April.	400 to 800 lbs. (up to 1200 lbs. in up-country.)	Often sown mixed with a millet. Not suitable for sandy soil or land subject to inundation Red clay loam best. Stands drought well. Chaitali *arahar* is bolder and keeps better. N.-W. P., Oudh and Behar seeds give better result in Lower Bengal than local seed. Best crop to grow from time to time for renovating soil. No irrigation necessary.
2. Gram.	End of October.	15 to 50 lbs.	February to middle of March.	200 to 400 lbs. (up to 1000 lbs. in up-country) 1000 lbs. of straw which is excellent fodder.	Gram requires no irrigation, either, but there should be sufficient moisture in the soil at sowing time and the land should be kept properly open for reception of nocturnal dews. If rains cease early, sowing can be done in Septr., but this is risky in Lower Bengal. Cotton, wheat, barley or rape is often sown with gram. Does best on the clay loam which is not too damp. Heavy rain or irrigation spoils this crop. Heads should be nipped off, or sheep let loose for a day or for a shorter time. Soils containing a good deal of lime are specially adapted for gram. The Cabul gram grown at Sibpur Farm is the best variety to grow.

Name of crop.	Time of sowing.	Quantity sown per acre.	Time of harvesting	Quantity harvested, per acre.	Remarks.
3. Kulthi.	October or November, if for grain. If for fodder, may be sown in dry regions in (1) June, (2) August and (3) November, three times on the same field.	20 lbs., if for grain, 25 lbs, if for fodder.	February if for grain; if for fodder (1) August or Septr. (2) Octr. or Novr. and (3) January. If this 3rd crop is seeded the grain is harvested in Febry.	300 lbs. of grain or 5 tons of green fodder, per crop.	Stands drought well. Is the staple horse-gram of S. India. Considered the best cleaning crop, like Aus paddy. No falling off of yield is noticed if 3 crops are taken in succession. Light dry soil is preferred. The grain being very hard should be given boiled to cattle and broken and wetted with water, to horses.
4. Popat.	July.	5 to 8 lbs.	Jany. and Febry.	250 lbs. to 400 lbs	This is a staple *dál* crop of the C.P. The pods resemble *shim* but they are inferior to Bengal *shim* as table-vegetable, though seeds inside the legume are quite as good to taste as haricot beans.
5. Soy bean (Gari kalai).	Beginning of November.	30 lbs.	End of March.	400 to 500 lbs.	This contains 400% of albuminoids Prof. Kinch of Cirencester drew the notice of the Govt of India to the fact. Grows abundantly in the Manipur and Naga hills. It is the richest pulse crop of China and Japan. Experiments should be conducted with a view to introducing this pulse in hilly tracts of other parts of India.
6. Khesari	October.	12 to 16 lbs.	March.	300 lbs. +400lbs of straw.	Usually sown when winter paddy is growing. In the Rarh, gram, teora or khesari, linseed, and sometimes mash-kalai, are sown together broadcast, in Octr., in wet rice land without any preparation. Khesari actually does better sown in this way. Gram and linseed fruit more profusely though the plants become shorter under this treatment.

Name of crop.	Time of sowing.	Quantity sown per acre.	Time of harvesting	Outturn per acre.	Remarks.
7. Musuri.	October.	12 lbs.	March.	350 to 750lbs. & same quantity of straw.	Better land than Khesari is chosen for this crop and more ploughing is necessary for this than for Kalai.
8. Bhringi	End of June.	8 lbs.	End of Sept.	200lbs & 800lbs of straw.	Rough, sandy or gritty soil is usually chosen. Usually grown along with *Juar* as fodder crop, in some of the upper districts of Bengal. Harvested before Juar.
9. Urd or Birhi or Katkiá Kalái.	June.	8 lbs.	Sept.	300lbs & 800lbs of straw.	Grown with Juar or Aus paddy, or separately. The cultivation of those pulses which grow in the rainy season should be extended. These should be sown in ridges and the ridging plough is therefore invaluable if Kurthi, Bhringi, Popat arhariá shim and Urd are grown.
10 Mash Kalái.	September in lower districts; 15th July to 15th August in Sonthal parganas and other hilly and dry districts.	8 lbs.	(1) Jany. (2) Nov.	300lbs to 600lbs & 400lbs to 800lbs of straw.	Grown largely on Aus lands, and *dearh* tracts. This is the staple *kalai* of the cultivator.
11. Mug or Mung	June (in high and dry localities.) October (in lower districts)	5 to 8lbs ,,	Septr. or Octr. (in high&dry localities) February (in lower districts.)	200 lbs to 500 lbs & about the same quantity of straw.	Red loamy soil or dry and sandy soils are chosen for this crop. In the N.-W. P. & the C. P mung is sown in dry and sandy soil at the commencement of the rainy season. This practice can be adopted in high and dry and rocky soils of Sonthal Parganas, Birbhum, Manbhum &c., where mung and kalai can be sown with juar. The sowing should be done in ridges if done in June or July.

Name of crop.	Time of sowing.	Quantity sown per acre.	Time of harvesting	Outturn per acre.	Remarks.
11. French beans.	Octr., Novr., & Decr.	20lbs.	December to March.	1600 lbs. to 2000 of green vegetables.	This is a fairly profitable crop to grow near large towns where there is a European population. Clay soil is better than sandy soil for beans.
12 Country peas.	Beginning of Novr.	10 lbs. if for grain 20lbs. if for fodder.	March & April.	250 lbs. or 3000 lbs. of green fodder.	Country peas are grown on *dearh* land after water goes down.
13. English peas	Novr. & Decr.	15 lbs.	December to March.	1200 lbs to 1500lbs. of green vegetables.	European or American peas are the best to grow near large towns, as table vegetables. Rich clay soil is better than sandy soil for English or American peas. Only about 20/- or 30/- Rupees per acre can be expected by growing beans or peas, even as English vegetables, of which 15 Rs. will go out in expense. French beans are more profitable than peas. Imported seed is better than even "Olonda" or "Patnai" or "Kábli" pea seed. European peas and beans are benefited by light irrigation Ashes and phosphatic manure are the best manure to use. Beans are benefited by organic manures (cowdung &c.)

The *expense* of growing leguminous crops generally is very little,—Rs. 5 per acre for the country pulses and Rs. 15 to Rs. 20 for European peas and beans.

Kalai, country peas, arhariá sim, bhringi, and khesari plants are sometimes grown only as green fodder for cattle. Sometimes two or more of the following crops, *viz.* rape, musuri, country peas, khesari, wheat, svèti-sorsè, barley, gram

and linseed are sown mixed together. Rape ripens first, then svèti-sorsè, then ordinary mustard, then musuri, then linseed, then matar, then khesari, wheat, barley, and gram.

351. In the N.-W. P. and Oudh where land is lighter and generally richer in lime than in Bengal, pulse crops give heavier yield. In the deltaic portion of Bengal pulse crops do not grow well, an excess of ordinary salt in the soil being very injurious to these crops. Well drained land annually renovated with silt produces the best pulse crops in Lower Bengal.

CHAPTER XXXII.

OIL-SEEDS.

THE principal oil-seed crops of India are, Brassica (rape and mustard), Linum usita tissimum, Sesamum indicum, Eruca sativa (tárámani), Carthamus tinctorius, Guiz-otia abyssinica, Ricinus communis, Papaver somniferum, Arachis hypogœa and Gossypium (cotton). The oils of the following trees and plants are also more or less largely employed: Anacardium occidentale, Bassia latifolia and other Bassias, Cocos nucifera, Helianthus annuus, Argemone mexicana, Melia azadirachta, Amoora rohituka, and Galedupa indica.

353. The recognised oil-seed crops of India occupy an area of about 12 million acres of which the Province of Bengal furnishes over 4 million acres, *i.e.* about 6·45 per cent. of the cultivated area of Bengal. Next to cereals, oil-seed crops occupy the largest area in Bengal. According to the

extent of cultivation of these crops the different divisions of Bengal come in the following order :—

	Acreage.	Proportion of cultivated area.
1st Chhotanagpur Divn.	... 823,200 acres	10·71 per cent.
2nd, Patna ,,	... 733,700 ,,	5·39 ,,
3rd, Dacca ,,	... 724,400 ,,	9·23 ,,
4th, Rajshahi ,,	... 675,600 ,,	8·21 ,,
5th, Bhagalpur ,,	... 500,300 ,,	4·96 ,,
6th, Presidency ,,	... 325,400 ,,	5·85 ,,
7th, Burdwan ,,	... 187,700 ,,	3·30 ,,
8th, Chittagong ,,	... 104,200 ,,	3·35 ,,
9th, Orissa ,,	... 84,800 ,,	2·66 ,,

The above table leads one to infer, that oil-seed crops do not need rich soils to grow, and they are more benefited by mineral (Phosphates, lime &c.) than by organic manures. Indeed, the value of Phosphatic manures for oil-seed crops have been proved by many experiments.

354. The enormous export trade in oil-seeds is a great loss to the country, and it is highly advisable to organise a system of pressing the oil in this country, exporting only the oil and retaining the cake for use as animal food or manure in the country. The export of oils from India is a little over 4 million gallons per annum, valued at about 50 lakhs of Rupees. Of this quantity three-fourths consist of castor-oil, which is highly valued for lubricating, soap-making and other purposes, in Europe. One and a half million gallons of cocoanut oil valued at 16 lakhs of Rupees, is the oil of next importance which is exported. Against this, there are about 16 million cwt. of oil-seeds, valued at over 10 crores of Rupees which are annually exported from India. The question of fertility of Indian soils is intimately blended with that of the export of oil-seeds and bones. To England goes most of the linseed. America also buys a good deal. The other oil-seeds go chiefly to the Continent. Eight million cwt. of linseed, 4 million cwt.

of rapeseed, nearly 2 million cwt. of *til*, over 1 million cwt. of earthnuts and nearly 1 million cwt. of castor-seed are exported to Europe and America.

CHAPTER XXXIII.

INDIAN MUSTARDS (BRASSICA JUNCEA, B. CAMPESTRIS AND B. NAPUS).

THE Bengal mustards have been studied closely by Major Prain, and according to him there are three distinct types of mustard, which may be distinguished thus :—

1*st*.—Indian mustard or Rái, the Sinapis ramosa of Roxburgh and Brassica Juncea of Hooker and Thomson.

2*nd*.—Indian Colza or Sarson, the swèt-rái of Central Bengal, very tall, grown all over Bengal except Chittagong (plants resembling turnip or swede), the Sinapis glauca of Roxburgh, and Brassica campestris, sub-species *genuina*, variety *glauca* of Hooker and Thomson.

3*rd*.—Indian Rape or Tori, the Sorshé of Central Bengal, the Sinapis dichotoma of Roxburgh, and Brassica campestris, sub-species *napus*, variety *dichotoma* of Hooker and Thomson.

356. Besides these staple varieties, there are some others also cultivated in some parts of Bengal, *e.g.* (1) Brassica trilocularis (Ulti Sarson), which is unlike ordinary *sarson* only in having pendent pods; (2) Brassica quadrivalvis which is a variety of Sarson which has four rows of seed instead of two; (3) Brassica rugosa, Prain, or the Kalimpang *rái*; (4) Brassica rugosa, var. Cuneifolia, Prain, grown by Cacharis and Rajbansis throughout Upper Bengal and Assam; (5) Brassica Chinensis or China Cabbage may be also regarded as a mustard. Indeed Turnip, Cabbage and

Cauliflower are botanically closely allied to mustard, all of which are included under the genus Brassica of Linnæus.

357. The black and white mustards (Brassica nigra and alba) of Europe are not grown in Bengal. It is from these that the mustard of European condiment and hospital poultice, are obtained. The oil of these mustards, though very useful medicinally as a very strong antiseptic, is not so suitable for food as the oil of Indian mustards, though the meal of European mustards is a better condiment.

358. First, Rai, Láhi, Li, or Ráichi-rái is grown in all the Divisions of Bengal except Chhota-Nagpur, where it is practically unknown, except in Singhbhum. It is easily recognised by having none of its leaves stem-clasping, and after reaping, its seeds, which are brown, can be readily distinguished from those of Tori or Indian rape, by their small size, and their being distinctly reddish brown all over. From *Sarson* which has white seeds, or, as occasionally happens, brown seeds, it is easily distinguished. *Sarson* seeds are always considerably, often very much, larger, and even when brown, have the seed-coat smooth. There are three sub-races of *Rai,* a tall late kind and two shorter earlier kinds, one of these latter roughing with bristly hairs, the other smooth with darker coloured stems. The taller sub-race is quite absent from Chhota-Nagpur and from Tippera and Chittagong. The shorter sub-races are quite absent from Orissa and are absent from North Bengal, except Tippera. *Rái* or *Rái-shorshè* is called *chhota-sarisha* in Orissa, because the seeds are small.

359. Second, Tori, Latni (Chhota Nagpur) and *Sarisha* or *shorshè* (Indian rape) is next in importance to *Rái*, and it is grown in every district in Bengal except perhaps Saran and Shahabad. It is easily distinguished from *Rái* by its stem-clasping leaves and its small size. When reaped the seed is recognised as being larger, though of the same colour, and by having a paler spot at the base of the seed; the seed-coat too is only slightly rough. From Sarson or Indian Colza it is easily dis-

tinguished by its smaller size and by its leaves, though stem-clasping, as in Sarson, being less lobed and having much less bloom. The seeds of *Tori* and ordinary *Sarson* are much of the same size, but as a rule the seed of *Sarson* in Bengal is white. When *Sarson* seeds are brown they are of an amber colour and they have no paler spot. The seed-coat is smooth. The seeds of *Sarson* are *sometimes* considerably larger than those of *Tori*. When this is the case the two are easily distinguished. There are *two kinds of Tori*, a taller, rather later, and a shorter, and very early kind which is the commoner variety. Both kinds however ripen well ahead of any *Rái* or any *Sarson*. The earlier kind of *Tori* probably does not occur in North-West Tirhut and the later kind is unknown in Eastern Bengal and Chittagong; with these exceptions both sorts prevail throughout Bengal.

360. Third, Sarson or Indian Colza, the *shwèti shorshè* or simply *shwèti* of Bengal, and Ganga-toria of Orissa, occur in every district except Chittagong, where it is replaced by a different mustard. It is easily distinguished from *Rái* by its stem-clasping leaves, and from *Tori* by the greater amount of bloom on its foliage, by its taller stature, its more rigid habit and its thicker and plumper pods. When reaped the seeds are distinguished by their usually white colour; when brown the seeds are distinguished readily from those of *Rai* by the larger size, and the smooth seed-coat, and from those of *Tori* by their being of a lighter brown, and by not having a paler spot at the base of the seed. There are two races of *sarson*, one with erect pods, the Natwa Sarson or Sarson proper and one with pendent pods or Tero Sarson. Each race has two distinct sub-races, one with 2-valved and the other with 3 to 4-valved pods. The forms with hanging pods are not common except in northern Bengal and eastern Tirhut (Purnea), the sub-race with 2-valed pods being almost confined to this area. But the 4-valved kind extends sparingly throughout western Tirhut and crossing the Ganges spreads southwards through southwest

Bihar and western Chhotanagpore. The forms with erect pods occur all over Bengal ; the 2-valved subrace, however, is not much grown in Bihar. The 4-valved subrace occupies west Tirhut and west Bihar and extends in a southwest direction to Midnapore. It is also grown in northern and north-eastern Bengal. Roughly speaking, the 2-valved erect Sarson is grown chiefly in Chhotanagpore, Orissa, and in west, central and east Bengal ; the 4-valved erect Sarson is grown chiefly in west Bihar and north Bengal ; and the pendent Sarson occurs in the area to the north of the Ganges beyond the region occupied by the 4-valved Sarson.

361. Fourth, the Chittagong mustard, which is closely allied to European colza.

362. Fifth, the Nepalese mustard, which is the same as the Cabbage-mustard of the Chinese cultivator.

363. Sixth, the China cabbage which is quite distinct from the last has been only lately introduced into Bengal jails.

364. Seventh, Eruca sativa or Tárámani (Tiramira) is commonly confounded with mustard. It also belongs to the natural order, Cruciferæ and *tribe* brassiceæ. The seeds are compressed and light reddish brown in colour.

365. Tori or Sorshè and Sarson or Swet sorshè are usually sown with wheat or barley, or in gardens with carrots and Ramdana (Amaranth), while Rái is usually grown by itself. They are sown in September *i.e.*, 6 weeks to 2 months before the regular *rabi* sowings. The sowing of *rái* is done earlier and it is harvested in February or March, while sarson and tori are sown and harvested later. There are however early and late varieties of all the three crops. When tori or sarson is sown with wheat or barley at the rate of 1½lbs., per acre, the produce is only 1½ to 2 maunds per acre. Sown by itself, at the rate of 4 to 6 lbs. per acre, the produce is 4 to 6 maunds. Rai is usually sown at 3 lbs. per acre and peas are sown afterwards on the same land. Grown in this way the outturn per acre of *rái* is 3 to 4 maunds. Grown by itself, without

peas, scarcely any higher yield is obtained. Rai seed yields less oil than sorshé and shwéti-sorshé seeds. In the former case the yield is 10 seers per maund and in the latter 13 to 14 seers. All the three varieties of mustard are sometimes grown as a green manure and sometimes for green fodder only, the plants being cut and given to cattle in January and February, *i.e.* when they are just in flower. Sometimes a crop of mustard is ploughed in as manure, but this form of green manuring has no such special merit as the ploughing in of *dhaincha*, sunn-hemp, indigo, or *barbati*.

CHAPTER XXXIV.

LINSEED (LINUM USITATISSIMUM).

THIS plant has been discovered in the wild state in the region between the Black and Caspian seas and the Persian Gulf, the original home of the Aryan race. It is one of the most ancient fibre plants of India being mentioned in Panini thus:—"*Atasi syat-uma-kshuma.*" Whether the "*Kshouma-bashan*" of the vedas is silk-cloth, or linen cloth, is doubtful. Probably the word *kshuma* was applied first to silk and afterwards to linen, as "*kshaume bashane bashanam agnimadhiyatam*" has always been understood in practice with reference to silken wedding robe. What is most ancient survives in the most ancient religious customs. Besides it is not at all certain that linen cloth was ever made in India. Flax is grown not for its fibre but for its seed in India and though the knowledge that linen fibre was obtained from the flax plant existed in ancient India the use of silken cloth has been prescribed for religious observances. The growing of flax for fibre instead of seed (fibre and seed cannot be both grown to perfection from the same

plants) with imported seed and by sowing the seed thick, has been tried with success in Tirhoot and elsewhere, and the experiment is worth repeating. The growing of white linseed, the oil of which is more valuable than that of the ordinary brown linseed, is another improvement which should not be lost sight of. White linseed grows quite as well as brown linseed at the Sibpur Farm.

367. The total area under linseed in Bengal is estimated at 742,000 acres only or 1·15 per cent. of the total cultivated area of the province. Champaran with 190,000 acres under this crop representing nearly 9½ per cent. of the total cultivated area of the district, is the most important linseed-growing district in Bengal. Nadia comes next with 42,000 acres, or nearly 4 per cent. of the cultivated area of the district. Gaya, Murshidabad, Palamau, Backergunge, Darbhanga, Mymensingh, and Burdwan may be also mentioned as each having more than 25,000 acres under this crop.

368. Linseed grows well on heavy land, and it is not suitable for light and raviny soils, which are particularly well adapted for mustard and *til* crops. In fact, linseed can be grown on *Aman* land which is unsuitable for *til* and mustard crops. In rocky sub-Himalayan tracts, however, linseed does very well. Wheat, gram and linseed require the same kind of land. Gram and linseed are usually grown together, gram doing well also on heavy loam, if it is fairly rich in lime. The sowing of linseed should be done early, and preparations may commence in September when the rains are still on, actual sowing being done immediately after or even before the monsoon is over, at the rate of 4 to 6 seers per acre. Sowing is sometimes done when the *Aman* rice is still standing. Water-logging does not do this crop so much harm, but thorough and deep cultivation is essential for this crop as for wheat. The seed may be scattered in between the lines of paddy and simply ploughed in. Sown later, linseed needs irrigation, but when the crop is in flower or nearly mature, rainfall does harm.

The plants are cut down when ripe, at the end of February or beginning of March, and the seed extracted by flailing. Six to eight maunds of seed being the average produce per acre. The straw is useless as fodder, and it is said, green plants of linseed eaten by cattle prove fatal to them.

369. The seed yields about ¼th its weight of oil. Linseed-cake is a more valuable cattle food and a more valuable manure especially for milch cows, than *rai* or *tori* cakes, though the butter produced from milk given by cows eating linseed cake is softer than that from cows eating mustard or cotton seed cake.

CHAPTER XXXV.

TIL (SESAMUM INDICUM).

LIKE white linseed, white *til* yields a more valuable oil. White *til* is often grown along with cotton as a *rabi* crop, while black *til* is grown along with a tall crop, such as juar, as a *kharif* crop. The high and light alluvial and poor and rocky Sub-Himalayan tracts are suitable for the *til* crop. Indeed all oil-seed crops prefer soils rich in mineral matters, *til* doing better on lighter classes of soils, either rocky or riparian. The total area under this crop in Bengal has been estimated at 346, 200 acres. The following districts may be mentioned as growing fairly large quantities of *til* and as being specially adapted for this crop :—

	acres.	Percentage of cultivated area
Mymensingh.	74, 300	2·38 per cent.
Patna.	30, 000	1·89 „
Jessore.	29, 100	2·31 „
Backergunge.	28, 800	1·98 „
Midnapore.	18, 000	0·87 „
Bogra.	14, 000	2·06 „

371. *Til* should be grown on poor soils provided they are not too low or heavy. It does not require such deep preparation of land as linseed does. Eight to ten seers of seed are used per acre when it is grown by itself. Both the varieties of *til* are grown in some districts, the coarser variety called *Bhadoi til* or *kat-til* is sown in January, and reaped in June or July, about 6 maunds being obtained per acre. The sowing of this variety of *til* is done in Birbhum on low *Aman* land after a *maghi* shower of rain. The seed needs husking and the oil extracted is rather thin and poor. The *Rabi til* is sown in August and reaped in November or December. 4 to 6 maunds being obtained per acre. The stooks of harvested *til* stalks should be left to dry in a standing position, the seed being afterwards detached by flailing.

372. Scented flowers being kept in between layers of *til*, and the *til* being sifted out next day, and this operation being repeated for a fortnight and the scented *til* afterwards pressed, yields *phulel* oil which fetches over Rs. 150 per maund, but the demand for this article is limited. The oil-cake is used not only as animal but also as human food mixed with *gur* or sugar. The yield of oil from *til* seed is about 45 per cent. About 25 per cent. of *phulel* oil is obtained from *til* seed treated with flower.

CHAPTER XXXVI.

SORGUJA OR NIGER OIL SEED (GUIZOTIA ABYSSINICA).

IT usually follows *Aus* paddy, and is sown in August, either by itself or with some pulse-crop (kulthi &c.) Rough and rocky laterite soil or light sandy soil is chosen for this crop. The preparation of land is of the simplest character. Two

ploughings followed by a laddering are all that is done before sowing. About ½ a mnd. of seed is sown per acre. The crop is harvested in November or December, the produce coming to only about 4 maunds, valued at Rs. 5 or Rs. 5-8as. per maund. A considerable proportion of land is under this crop in the Chhotanagpur Division.

374. The yield of oil is about 35 per cent. of the weight of the seed. The oil-cake is highly appeciated for milch-cows in the Deccan, but it is doubtful if it is really very valuable. Mr. Mollison speaks highly of this oil-cake as a manure for the sugar-cane crop. Mustard and castor oils are adulterated with *sorguja* oil. The relative value of rape seed and *sorguja* seed in the English market is 48*s.* : 37*s.* per quarter. While rape seed yields 20 gallons of oil per quarter in England, *sorguja* seed which dries up quicker yields only 16 gallons per quarter, but a mixture of *sorguja* with rape actuall yincreases the yield of oil of the latter seed. Hence the universal use of *sorguja* seed for mixing with mustard seed before pressing oil out of the latter seed.

375. For making paints, for lubricating and for lighting, this oil is useful, and it is used in some parts of India for cooking and for anointing the body.

CHAPTER XXXVII.

CASTOR (RICINUS COMMUNIS).

THE value of this crop is of a two-fold nature: (1) the Eri silk worms are reared on its leaf and (2) the oil extracted from castor-seed is highly valued for lubricating machinery, for dressing tanned hides and skin, for lighting, for soap and candle-making and other arts, and lastly as a medicine. The large seeded varieties are appreciated for extracting lubricating and lighting oils, while the small seeded varieties, for extracting a fine quality of oil used for medicine. The slow-

ness with which castor-oil burns, effects a saving of consumption ranging from ¼ to ½ in comparison with other lighting oils, such as kerosine, mustard oil, linseed oil etc. Being comparatively freer from danger and giving little soot it is used in railways all over India. The qualities of castor-oil for keeping the head cool and the pores of the skin and roots of the hair soft and open, are availed of in the manufacture of golden-oil, pomatum and perfumed oils of various kinds. Cold-drawn castor-oil gives more brilliant light than castor-oil from boiled or roasted seed. The oil therefore extracted from unheated shelled seeds is more valuable. The present price of cold-drawn castor-oil is Rs. 40 or 50 per maund, the extraction of this oil from the seed being mostly done in Europe. The manufacturing of cold-drawn castor-oil in India offers a great opening for capitalists. A high class varnish for polishing furniture, oil-painting, maps etc., is prepared out of castor-oil, by dissolving it in alcohol and incorporating into it an alcoholic solution of copal or East Indian dammar. Castor oil agitated with nitric acid is used for lubricating wheels of railway carriages. Castor cake is the best vegetable manure there is. This cake is also used for extracting gas which is actually in use in the Allahabad Railway station for lighting purposes. The East Indian Railway Co. have their own castor-oil mills and they use the oil and cake both for lighting. Castor-oil is also in use for extraction of gas for lighting the streets of Jeypur. As a manure, castor-cake and bone-meal together have been found better for sugar-cane than the cake alone, while for rice and potatoes castor-cake alone has given the best result in India. Castor-cake is considered injurious to the *pan* plant, the manure used in *pan barojes* being mustard-cake. It is a common mistake to suppose that castor-cake is richer in phosphates than linseed or rape-seed cakes. Poppy-seed cake is the richest in phosphates and castor-cake is not any richer than rape or linseed cake in this respect.

377. It is very curious that while castor-oil plant leaves eaten by milch cows help to increase the flow of milk, a pulp made out of castor leaves is used externally by women to stop the flow of milk from their breasts. Sometimes whole leaves are applied to the breasts for this purpose. The dried stalks are used for thatch and as wattle and also as fuel. The stalks are not attacked by white-ants.

378. The *yield* of oil is about 25% to 36% of the weight of seed, and of cake from 36 to 44%, the rest being husk etc., which has to be got rid of before the oil is extracted.

379. The *cultivation* of castor-oil plant is done chiefly in the Patna and Bhagalpur Divisions. In other parts of Bengal also it is grown more or less abundantly. A small sized, a middle sized and a large sized variety, are recognised. The first and the last are sown from May to July and grown with some *bhadoi* crop. The seeds ripen in January and February. The winter variety is sown in September and the seeds are gathered in March or April. This variety yields a larger proportion of oil than the *bhadoi* varieties. On *dearh* land the cost of cultivation is little and the yield is large. Like other oil-seed crops, the castor crop is benefited by mineral manures, and the annual renovation of soil by silt is an appropriate substitute for manure. Red soils situated at the foot of hills are also specially chosen for growing castor-oil plants. Such soils if very poor in organic matter, get an application of 20 to 30 cartloads of dung (7 or 8 tons) per acre, or flocks of sheep are hurdled on them. Two or three ploughings are then given at the commencement of the rainy season and the seed sown by dibbling 1½ yds. apart, about 6 lbs. of seed being used per acre for the larger variety. In each hole 2 seeds are put in, and if the soil is too dry at the time, water is put in each hole before it is covered up. The smaller variety is planted 18 ft. × 36 ft. apart, 4 lbs. of seed being used. Castor is an exhausting crop, and it should not be grown on the same land oftener than once in 5 or 6 years.

It is never irrigated, which is a great advantage, all the operation necessary after sowing being ploughing the land a month after sowing in between the rows of seedlings, to keep it free from weeds.

380. Castor plantations being very much subject to the attack of caterpillars, preparation of land in the cold weather is necessary, that grubs may be exposed to the attack of birds and ants, also stirring of the soil once a month until sowing time. The seed should also be pickled with an insecticidal mixture before sowing.

381. The *picking of capsules* continues from the 7th to the 9th month after sowing, after which the remaining leaves are given to cattle and the stems cut and used for fuel, or for making charcoal which is used in the preparation of fire-works. The seed-pods are stacked in a corner of a house, covered with straw and weighted. After a week the capsules are found soft and rotten. They are then exposed to the sun for 2 days, dried, and beaten with heavy mallets 2 ft. long × 1½ ft. broad, which process extracts about half the seed. The remaining capsules are again dried and beaten, until all the seeds have been extracted.

382. A small seeded Deccan variety goes on bearing for 5 years in succession. The quality of oil of this variety is also superior.

383. When castor is grown with other crops the *yield* of cleaned seed per acre is about 250 lbs., while grown by itself, the yield comes to 500 to 900 lbs. per acre. The cost of cultivation being very little (about Rs. 10 per acre), it is a profitable crop to grow.

384. There are four processes of extraction of oil which can be followed without much difficulty :—

(1) The seed may be crushed in a screw-press with horizontal rollers and the resulting pulp put into *ghanies* and pressed. This cold-drawn castor oil can be obtained at as high a proportion as 36 per cent., 37 per cent. of cake and 27 per cent. of husk being also obtained.

(2) The seed may be roasted in a pot, pounded in a mortar and placed in four times its volume of water, which is kept boiling. The mixture is constantly stirred with a wooden spoon. After a time the pot is removed from the fire and the oil skimmed off. The residue is then allowed to cool and next day it is again boiled and skimmed. The second day's skimming gives better oil which is kept separate. If the beans are over-roasted a smaller proportion of oil is obtained. The proportions of oil to cake &c. obtained by this method are 30½ per cent. of oil : 43½ per cent. of cake : 26 per cent. of husk wastage.

(3) The seed may be first boiled and then dried in the sun for 2 or 3 days, then pounded in a mortar, placed in 4 times its volume of water which is kept boiling, while the mixture is stirred with a wooden spoon as before. The skimming of the oil takes place as in process No. 2. The oil thus obtained is a superior lamp-oil to that obtained by process No. 2, though it is inferior to that obtained by process No. 1.

(4) The seed may be soaked for a night in water, and next morning ground up in an ordinary *ghani*. The oil is removed gradually by putting a piece of cloth into the pulp and squeezing the oil out of the cloth into a pot. This oil is also a better lamp-oil than that obtained by roasting the beans. This process gives the best oil-cake.

385. That cold-drawing with proper machinery gives a larger yield ought to encourage capitalists to adopt this method of extraction more and more. After the cold-drawn oil has been obtained by pressing the kernels in gunny bags, it is put in galvanized iron vats and bleached by exposure to the sun, which also causes the sediment to precipitate. The oil is then filtered through vegetable charcoal and flannel bags. In the Rajshahi Jail, fire is put underneath the machine when the kernels are pressed in canvas bags. This increases the yield of oil by 10 per cent., but some of the irritating and noxious

properties of the seed go into the oil which make it unsuitable for medicinal purposes. But cold-drawn medicinal oil is also made in this jail. The processes adopted in jails are:—

(1) Cleaning and grading of the seed with hand.

(2) Splitting of the seed with mallets, or with machine, consisting of 2 iron rollers, set parallel to each other and at adjustable distance.

(3) Sunning the seed and winnowing it with *kulo* or *sup*, so as to separate the kernel from the husk on a wide masonry platform.

(4) Crushing the kernels with *dhenki*, or with another roller machine.

(5) Putting the pulp into canvas bags 15″ × 12″ and pressing it in screw presses in between plates of iron, about 150 bags being put in at each feed of the press.

(6) Boiling (40 parts of oil with 5 to 8 parts of water) in copper pans; great experience is needed for this operation.

(7) Straining through a bed of charcoal and 8 folds of calico.

386. The growing of castor in plantations for the purpose of rearing Eri silkworms on a large scale cannot be recommended. Eri silk rearing, to be profitable, must be carried on as a domestic industry by the poor. Poor delicate women who have no other avocation in particular, can profitably employ their time in rearing a few thousand silkworms in-doors on *dalas*, picking leaves from near the immediate vicinity of their homesteads, utilising the cocoons for spinning thread with wheel or *takur* (spindle) and weaving a coarse but substantial cloth out of it. Two or three pieces of *chadder* cloth woven annually by a woman would bring her a gross outturn of Rs. 36, with no outgoings whatever. This in some districts would be considered a profitable industry for women.*

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* Readers desirous of getting fuller informatoin on the subject should consult the Hand-book of Sericulture by the author.

CHAPTER XXXVIII.

GROUND-NUT (ARACHIS HYPOGAEA).

THIS is a native of America, introduced into India probably through China about 60 years ago. It grows best on dry, sandy soil, and it is cultivated chiefly in the light soils of the Madras Presidency. The seed can be put down either in February, or in May or June, or in September and October, or in fact, at any time except during the two rainy months. Sown in May or June the crop can be lifted in November and December, and sown in September or October the crop can be lifted in March or April. In heavy clay soils, the cost of lifting the crop is not covered by the value of nuts obtained, and so many nuts remain behind undiscovered in the unbroken clods that the plants come up always afterwards like weeds. In such soils flooding should be done before lifting which makes digging easier. In light soils the yield is larger and the cost of cultivation less. In heavy soils it can however be grown as a fodder crop only which is of high value for milch cows. It does not require irrigation unless sowing is done at a dry season and it grows without any trouble. Grown year after year in tracts near Pondicherry, the crop has degenerated and has become subject to diseases. It is necessay to observe the principle of rotation in dealing with this crop as with other crops. A judicious system of manuring with ashes and lime is also a desideratum. That the crop seems to stand a good deal of neglect and does equally well at first with or without manure, are facts which have the tendency of throwing cultivators off their guard, as after taking several crops successfully out of the same land they are surprised that the crop should show a tendency to deteriorate all of a sudden. This is the case now with the ground-nut cultivation of the Madras Presidency which is threatened with ruin. The demand for ground-nut and ground-nut oil is very great especially in France, and

light soils in Bengal may be chosen for growing this crop in a judicious manner, that the demand may be met from Bengal *paripassu* with the failure of supply from Madras. Half a mnd. of seed may be sown per acre at a distance of 9″ either way. The outturn may come to 40 mnds. per acre.

388. The oil burns slowly but it does not give a brilliant light. It is almost as good as olive oil and is largely used even for medicinal purposes as a substitute for olive oil. It does not get rancid so quick as other oils do. It is largely used for adulterating cocoanut and other oils. In Europe it is extensively employed for soap making, for dressing cloth and for lubricating machinery. The yield of oil is about 40 per cent. It is unfortunate that the export should be chiefly in the form of nuts and not in the form of oil only, as the cake would be of great benefit to the country as a food and as manure for soil. European machinery should be imported for extracting the oil before export from this country. France imports about 100,000 tons of ground-nuts per annum of which India supplies only 7,000 tons, the rest being imported from the Western coast of Africa. French India exports five times as much as British India, as the demand for this article is almost confined to France and Belgium, and the port which is principally concerned in the export of the article is Pondicherry.

389. The ground-nut oil-cake fattens cattle very rapidly. Indeed it has been recommended as a highly nutritious and agreeable human food in a cooked condition. The cake is actually richer than peas and lentils in flesh-forming matter, while it contains more fat and phosphoric acid than pulses. The percentage composition of the cake is given below :—

Moisture	9·6
Fat	11·8
Nitrogenous matter	31·9
Sugar and starch	3·78
Fibre	4·3
Ash	4·6

CHAPTER XXXIX.

POPPY (PAPAVER SOMNIFERUM).

AFTER extraction of opium from the poppy capsules, the ripe seed loses its bitter and narcotic principles, and it is then a wholesome article of diet. Poppy seed is largely consumed. Even after the extraction of oil, the residue or oil-cake is eaten by poor people. Poppy seed-cake is richer in phosphates than other cakes. The oil is extracted by pressing with the ordinary *ghani* and it is clarified simply by exposure in shallow vessels to the sun. Poppy oil is used in Europe for making candles, soap, paint and artists' colours. The average produce of seed per acre is 3 mnds. and the yield of oil about 13 srs. per maund. One and a half srs. of seed are sown per acre. The seed sown in Malwa is imported from Persia.

391. The cultivation of poppy, which is mainly a drug-crop, will be dealt with in a connection with Opium. As by law the cultivation of this crop is restricted, the subject is of no general interest to the cultivator.

CHAPTER XL.

COCOA-NUT (COCOS NUCIFERA).

ALTHOUGH in the ordinary sense cocoa-nut cannot be regarded as a crop, yet cocoa-nut oil is so extensively used in India, and so largely exported, that it should find a

place in our description of the oil-seed crops. The area under cocoa-nut in India has been estimated at 480,000 acres. The tree is put to such varied uses that it can be regarded as much in the light of an oil-crop as in that of timber, fibre, fuel, vegetable, fruit or miscellaneous crop. A vinegar is made of the juice of this palm, also toddy, punch and liqueur. *Gur* and sugar are also made out of the juice. Soap and candle made out of cocoa-nut oil has a larger percentage of water than any other soap and candle. Being soluble in saline or hard water, it is used in the manufacture of marine soap, but the smell being offensive it is not used in the manufacture of high class toilet soaps. One to two million gallons of cocoa-nut is exported annually chiefly to England.

393. The sliced kernel, dried in the sun, or artificially dried, contains from 30 to 50 per cent. of oil. The methods of extraction of oil fall under two heads: (1) Dry expression, (2) Extraction by boiling.

(1) Half a cwt. of dried kernel is a charge for a full sized *ghani* and a pair of stout bullocks will get through 4 charges a day, so that 20 *ghanis* are required to get through 2 tons of kernels in 24 hours. The man who drives has a boy to assist him in taking oil which is got out of the mortar by dipping a piece of rag into the fluid and squeezing it out into an earthen vessel, but if the bullocks are trained the boy can be dispensed with.

(2) The second process consists in boiling the kernels with an equal quantity of water, then grating and squeezing in a press. The emulsion then obtained is again boiled until the oil is found to rise to the surface. Fifteen to twenty nuts yield 2 quarts of oil treated in either way.

The first method is the one commonly employed.

394. The merits of coir as a rope-fibre, possessing elasticity and lightness and a high power of resistance to the action of water are now recognised all over the world. About 10 million pounds of coir and coir-made rope are now exported

annually from India. Fifty cocoa-nuts yield about 6 lbs. of coir. About 6 lakhs of Rupees worth of *nuts* are also exported annually from India.

395. An acre planted with 200 cocoa-nut palms (about 15 ft. apart) would yield in coir alone 2 to 2½ annas per tree or nearly Rs. 30 for the 200 trees. The average yield of fruits may be put down at 8 annas per tree or Rs. 100 per acre. But the plantation to yield so much must be situated within 100 miles of the sea-coast, that sea-breez- may bring enough of salt into the soil to keep up its vigour for this crop. At the time of planting also, half a seer of *khari nimak* should be used per plant. The seed cocoa-nuts used should, if possible, be imported from Ceylon or Madras.

396. The cocoa-nut flowers in about 5 years after planting, in the hot weather. The nuts are ripe and ready for plucking in 10 months after flowering. Nuts allowed to remain too long on trees, the fibre gets coarse and brittle. The fibre of green nuts is lighter and finer, but there is less quantity and it is weaker. The removal of the fibre from the shell is effected by forcing the nut upon a pointed implement stuck into the ground. With this arrangement one man can clean 1,000 nuts a day. The fibrous husks are next submitted to a soaking, which is variously conducted. In some places they are placed in pits of salt or brackish water for 6 to 18 months (fresh water spoiling the fibre). If steam is admitted into the steeping vat to warm the water, the operation is rendered shorter and the fibre is also softened and improved. The further separation of the fibre from the husk is largely effected by the hand. After thorough soaking the husks are beaten with heavy wooden mallets and then rubbed between the hands, until all the interstitial cellular substances are separated from the fibrous portion. When quite clean, it is arranged into a loose roving preparatory to being twisted, which is done between the palms of the hands in such a way as to produce a yarn of two strands at once.

Analysis of cocoa-nut.

	Husk.	Shell.	Kernel.	Milk.
Total weight per cent. ...	57·28	11·59	18·54	12·58
Moisture „	65·56	15·20	52·80	nearly 100
Dry matter	34·44	84·80	47·20	Trace
Nitrogen ...	0·137	0·100	0·504	Do.
Pure ash	1·63	0·29	0·79	0·38
Including ...	...		...	...
Silica(SiO_2) ...	8·22	4·64	1·31	2·95
Oxide of iron and alumina (Fe_2O_3 and Al_2O_3) ...	0·54	1·59	0·59	Trace
Lime (CaO) ...	4 14	6·26	3·10	7·43
Magnesia (Mgo) ...	2·19	1·32	1·98	3·97
Potash (K_2O) ...	30·71	45·01	45·84	8.62
Soda (Na_2O) ...	3·19	15·42	...	...
Potassium chloride (KCl)		...	13·04	41·09
Sodium chloride (Nacl)	45·95	15·56	5·01	26·32
Phosphoric acid (P_2O_5)	1·92	4 64	20·33	5·68
Sulphuric acid (SO_3)	3·13	5·75	8·79	3·94

1000 nuts remove from the soil	Husk. lbs	Shell. lbs.	Kernel. lbs.	Milk. lbs.	Total. lbs.
in N	3·7017	0 5460	4·4100	Trace.	8·6577
P_5O_5	0 8456	0·0735	1·4053	0·1279	2·4523
K_2O	13·5255	0·7127	3·7362	0·7783	18·7527
CaO	1·8234	0·0991	0·2143	0·1674	2·3042
NaCl	20·2375	0·2464	0·3563	0·5431	21·4235

In analysing cocoa-nut fibre, Mr. Hooper of the Economic Museum in Calcutta, has discovered a large proportion of Salycilic acid.

CHAPTER XLI.

COTTON (GOSSYPIUM).

COTTON as a fibre-crop will be separately dealt with and the cultivation of the crop will be treated in a future chapter. We will discuss here its oil yielding quality only. Up to the time of the American war of Independence cotton-seed was regarded as a useless article. In India, even now it is thrown away in many places as a useless article; but in many places also the seed is given to cattle, especially to milch-cows to increase the flow of their milk. In the Nagpur Experimental Farm, 2 seers of cotton-seed per diem are given to each bullock in place of oil-cake. The extraction of oil is practically unkown in India and in fact the Indian varieties of cotton yield very little oil. Decorticated cotton-cake is considered the best oil-cake both for feeding cattle and for fertilizing the soil. It is almost as good as Bengal and N.-W. Provinces castor-cake as a manure, containing 6 to 7 per cent. of N against 6 to 8 per cent., which is the proportion of N in castor-cake. The ash of cotton-cake is particularly rich in phosphoric acid, potash and lime, the constituent of the ash being shown below :—

Potash	... 35·440
P_2O_5	... 30·016
Lime	... 4·450
MgO	... 15·067
Soda	... 0·810
SO_3	... 3·222
Fe_2O_3 and Al_2O_3	... 1·075
Cl	... 0·490
CO_2	... 3·465
Sand &c.	... 5·965
	100·000

398. The most economical way of applying cotton-cake and other edible oil-cakes, to the soil, is to use them as cattle-food, on the land intended to be enriched, the cattle being hurdled in here and fed in movable troughs.

399. The colour produced in cotton oil by sulphuric and nitric acids, is a characteristic mark of great value. This varies from a deep reddish brown to almost black. Cotton oil has also the remarkable property of reducing silver compounds into the metallic state. It is intermediate in properties between drying and non-drying oils. It has a pleasant taste and it is almost odourless and it is therefore used for cullinary purposes, and as a substitute for olive oil. Having drying property it is unsuitable for lubricating purposes. It is not adapted for medicinal use in place of olive oil. The use of cotton oil for medicinal purposes is pure adulteration which is forbidden by law. It is an important oil for the soap-making industry.

400. For every pound of lint there is about 3 lbs. of seed. 100 lbs. of American cotton seed yield about 2 gallons of oil, 48 lbs. of oil-cake and 6 lbs. refuse oil fit for soap-making. With ordinary *ghani* 25 per cent. of oil can be obtained from the seed but the seed should be very free from adhering cotton. The use of cotton gins is highly desirable in India, as the separation of seed in a clean state may be quickly effected thereby. A small hand-gin would yield 100 to 150 lbs. of lint and 300 lbs. of clean seed per diem. Grinding establishments in the midst of cotton-growing districts may well be employed in extracting oil and supplying oil-cake. This is an industry for which there is a fine opening in India. It is the income from seed that makes all the difference in America between a profitable and an unprofitable cotton crop. The magnitude of this opening in a new direction can be inferred from the fact that India produces about 10 million cwt. of cleaned cotton. This represents about 30 million cwt. of seed. Allowing half this quantity as required for seed and

feeding of bullocks in localities where the seed is used for feeding bullocks, nearly 700,000 tons would be still available for extraction of oil for export and obtaining of oil-cake for cattle food and manure. 100 to 200 lbs. of clean cotton and 300 to 600 lbs. of seed may be taken as the yield per acre. In Bengal the average yield of cleaned cotton is 100 lbs. per acre or even less. The most important cotton-growing districts are:—Saran (31,000 acres), Chittagong Hill Tracts (28,000 acres), Cuttack (20,000 acres), Lohardaga (15,000 acres), Darbhanga (12,000 acres), Midnapore (10,000 acres), and Manbhum (10,000 acres). The best cotton lands in Bengal are the Chittagong Hill Tracts, Midnapore, Cuttack and Jalpaiguri. These districts are mentioned here as possible centres for a new and important industry. European planters can be first induced to use the oil-cake as cattle food and manure and the use of these substances gradually introduced through their means among native cultivators.

CHAPTER XLII.

MAHUA (BASSIA LATIFOLIA &C.).

AS a sugar and fat yielding tree the Bassia Butyracea is of greater value than the common Bassia or *mahua* tree. This tree which is also called the Indian Butter tree grows in the Sub-Himalayan tract between Kumayun and Bhutan at 1,000 to 5,000 ft. above the level of the sea. The pulp of the fruit and even the cake left after the expression of oil

are eaten by men. The flowers are not eaten like the flowers of the ordinary *mahua* tree but from them, a syrup is prepared which is boiled down into sugar. It is equal, if not superior, to ordinary date-sugar. The *gur* having small grain fetches a smaller price. The oil is used as a substitute for *ghi* and largely employed for adulterating *ghi*. It burns with a bright light without smoke or smell and it makes excellent soap and candles. This tree has not been taken such notice of as it deserves. The oil is extracted in the following way. The seed is beaten to pulp and put in bags and subjected to pressure until all the fat is expressd. About 35 per cent. of fat is obtained out of the seed. It is largely used mixed up with attar as a hair oil by up-country people who call the fat *phulwa*.

402. The common Mahua tree which is found abundantly in the dry and stony regions of Bengal is highly appreciated by the poorer people for its edible flowers which drop in abundance in March and April. The fruits from which an edible oil is extracted ripen 3 months after the shedding of the flowers. In Famine times the Mahua tree is regarded as a life-saving tree. The timber of the Mahua tree is also of considerable value and in dry and arid regions in the plains where ordinary agricultural pursuits prove difficult, the propagation of this tree should be encouraged as much as possible. The dried flowers being steeped in water and allowed to ferment, yield a spirit by distillation which is largely consumed by aboriginal tribes. Over 6 gallons of proof spirit can be produced from 1 cwt. of Mahua by European methods of distillation. Each tree yields 5 to 8 maunds of fresh flowers, which give about 1 maund of dry food. The dry flowers are an excellent fattening food for cattle. They keep very long and they seem to resist the attack of weevil.

403. The Mahua oil is extracted from the kernel of the fruit. The kernels are taken out from the smooth chestnut coloured pericarp by being bruised, rubbed and subjected to

moderate pressure. They are then ground and the oil obtained by expression. In the C.P., the kernels are pounded and boiled and then wrapped up in 2 or 3 folds of cloth and the oil thereafter expressed. In the western tracts of Bengal and in the C. P., the oil is largely used for lighting and as a substitute for *ghi*. It is of equal value with cocoa-nut oil for soap-making and has been valued at £35 per ton in London.

CHAPTER XLIII.

SAFFLOWER (CARTHAMUS TINCTORIUS).

THIS crop is grown both as a dye-crop and as an oil-seed crop. In the C. P., safflower oil, though it is slightly bitter, is in common use for cullinary and other purposes and it is sold at about 200 tolas per rupee like any other ordinary oil. But it is chiefly for its red dye that it is cultivated all over India as well as in Spain, Southern Germany, Italy, Hungary, Persia, China, Egypt, South America, and Southern Russia. It is found in a wild state in the Punjab and elsewhere, the seeds of the wild safflower being much smaller than those of the cultivated kind. Safflower dye being evanescent and aniline colours gradually replacing it, the cultivation of this crop is gradually dying out. In Eastern Bengal, specially in Dacca and also in Midnapore, the cultivation of safflower for dye still holds its own.

405. It is usually sown along with some other *rabi* crop, such as gram, wheat, barley, tobacco, chillies, opium, or carrots, from the middle of October to the end of November. In Chittagong sowing is done as late as January. Low *chur*-land is preferred for this crop. It is an exhausting crop and grown for three years in succession on the same soil it is

known to yield very poor crops. In Jessore the crop is grown both on low lands and on high lands and it is found that the crop on high lands comes on earlier. It requires a light, well ploughed sandy soil, with a fair amount of moisture, and on high land it does not succeed unless there are three or four showers of rain or as many irrigations during the early stage of the plant. It is therfore usually grown as a subsidiary crop along with others that require irrigation and weeding. Rain is very injurious to the crop after the flowers have formed as the dye is washed out by rain. The central bud is usually nipped off to encourage side shoots and the growth of a larger number of flower heads. The flowers or rather florets are picked every 2nd or 3rd day, in January and February. They must be picked when they begin to get brightly coloured. Delay causes weakening of the dye. The picking of the flowers in favourable seasons may go on through March and even up to May. As fertilisation usually takes place before the picking the removal of the florets from the heads does not interfere with the subsequent formation of seed which is gathered afterwards for oil. The price of the dry florets varies from Rs. 20 to 30 per maund. The average yield of dry flowers is about 80 lbs. per acre and of seed 400 lbs., 16 lbs. of seed being broad-casted per acre when it is sown by itself. In the C. P. there is a thorny variety grown for oil which is especially adapted for growing round fields as a protection against cattle. The spineless variety is preferred for flowers.

406. *Dye.*—The florets are dried in shade (as exposure to sun weakens the dye) and sold afterwards; or sometimes the dry florets are powdered and sifted. The first and the last pickings give inferior dye. The pickings in the middle of the season give the best result. The dry florets contain two yellow and a red dye, the latter being sought for in preference to the former. The yellow dyes have to be first extracted. One of them is highly soluble in water and if the florets are

kept on basket and if clean river water (slightly acidulated, as alkaline water washes out the red dye) be poured on them yellow dye will be found coming out. Trampling or kneeding is continued at intervals while the yellow dye is being washed out, the operation taking 3 or 4 days, the mass being allowed to get dry between the washings. To ascertain if all the yellow colour has been removed, a small quantity of the stuff is thrown into a glass of clean water and it is seen if any yellow colour comes out. The pulpy mass is now squeezed between the hands into small, flat, round cakes, which when dry are sold in the market or exported as "stripped safflower."

407. The quality of safflower cake is estimated by dyeing a known weight of cotton. 4 ounces of safflower will dye 1 lb. of cotton cloth light pink; 8 ozs. will dye it rose pink; 12 ozs. to 1 lb. will dye it full crimson. The cotton must be dyed several times in fresh solutions that it may take up the whole of the dye. The red dye of safflower is Carthamin or Carthamic acid ($C_{14}H_{16}O_7$). Cold water or oil removes only one of the two yellow dyes in safflower which form 26 to 36 per cent. of the weight of the dry florets, while there is only ·3 to ·6 per cent. of Carthamin. The second yellow dye is removed in this way. Acidulate with acetic acid the "stripped safflower," filter, add acetate of lead and then ammonia to the filtrate and the second yellow colour will be precipitated along with lead salt. To extract carthamin in a pure state take carbonate of soda (washing soda), 15 per cent. of the weight of florets, after both the yellow dyes have been got rid of; digest the florets in the alkaline solution; filter and then precipitate the dye (which is insoluble in acids) by addition of an acid. In India pearlash from *bajra* or saji is used for obtaining the red dye.

408. *Oil.*—The dry husk is removed by pounding in *dhenki*. The oil is expressed in *ghani*. 1 mnd. of seed yields 7 srs. of oil, 14 srs. of oil-cake and 19 srs. of husk. The oil-cake is considered a very good manure for sugar-cane, &c.

409. *Other economic uses.*—It is due to Dr. Watt that a most valuable property of safflower oil has been only recently brought to light. Boiled slowly for 4 hours the oil becomes the best water proofing material hitherto known. It can be mixed with black oxide of manganese, or white lead, or yellow ochre, and the boiled oil so dyed applied with a brush on canvas or drill, or any other cloth to convert it into paulin or water-proof cloth. The boiled oil poured into cold water becomes a rubber-like substance which can be used as a cement for sealing glass or fixing ornamental stones or tiles on walls. For this purpose it is a much better substance to use than Plaster of Paris. It is this rubber-like substance that is applied on ornamental cloths made in the Punjab, to preserve the ornamentations in tact. A small proportion (say 1 : 400) of arsenic should be used if the rubber-like substance is meant to keep out the attack of insects permanently.

CHAPTER XLIV.

MINOR OIL-SEEDS.

HELIANTHUS annus (*sunflower*).—Sunflower oil is also used in Europe as a substitute for olive and almond oil for cullinary and table uses and it is largely used in Russia. For candle and soap-making it is superior to most oils. Sunflower seed and oil-cake are a valuable food for cattle. Poultry, pigeons and rabbits are specially fond of the seed. Experiments conducted in India have shown that it is a costly crop to grow. The leaves and stalks are eaten by cattle and they make a fairly good manure. The stalks may be also used as fuel and the ashes employed as a potash manure.

As a garden plant only, yielding seeds which are useful for feeding home poultry, its propagation can be encouraged but not as a regular oil seed crop.

411. *Anacardium occidentale* (*cashew-nut* or *hijli badam*).—Originally a native of South America, this tree has established itself in the coast forests of India,—in the Contai Sub-division of Midnapore, in Orissa, in Chittagong and in Madras. A weak solution of the gum of this plant which is very slightly soluble in water may be used as a preventive against the attack of insects. To this may be added a little asafœtida and a little aloe to make it more effective. The juice issuing from the bark is used as an indelible marking ink like *bhela*-nut juice. The bark is used for tanning. The ripe fruit is eaten. The pericarp of the seed which is partly outside the fruit, contains an acid oil, black in colour, which is a good preventive against white ants and which is used for tanning or colouring boats and fishing lines and fishing nets, like the mesocarp of the *gab* fruit. The kernels of the seed are delicious eating, and about 40 per cent. of an oil which is equal to almond oil and superior to olive oil obtained from the kernels.

412. *Amoora rohituka* (*Pittaraj*).—The oil from the seed of this tree is used in some parts of Northern and Eastern Bengal as a lamp oil. The seeds are fried and bruised, then boiled with water, when the oil floats on the top. The timber is good but little used.

413. *Nim seed* being very common, the value of *nim* oil as an antiseptic and anthelmintic veterinary medicine, and of *nim* oil-cake as a fertiliser containing 5 to 5½ per cent. of N and about 1½ of P_2O_5, should be here mentioned. The oil can be painted on young cocoa-nut and other trees to protect them against insect pests. *Nim* bark is nearly as effective in the treatment of intermittent fever as cinchona or arsenic. In a district where *nim* trees are plentiful the crushing of the *nim* seed for oil and oil-cake may be taken up as a

secondary mill industry in connection with a cotton-ginning and cotton-seed-crushing establishment, for instance. The propagation of Bassia latifolia, B. Butyracea, and *nim*, as a secondary industry, may be also undertaken by the Forest Department.

414. The *kenja* oil and *siálkántá* oil, as lamp-oils, need be only mentioned here as being actually in use. In Orissa the cultivator who possesses twenty Gadelupa (Kenja) trees, considers himself quite independent in the matter of lamp-oil. *Siálkántá* oil is used chiefly among the Sonthals of Rajmehal.

CHAPTER XLV.

DRYING AND NON-DRYING OILS.

THE principal drying oils are obtained from the following plants :—

Juglans regia (walnut, *ákrot*) which yields ...	50% of oil
Carthamus tinctorius (safflower, *kusum*) which yields about ...	25 ,,
Guizotia abyssinica (niger seed, *sorguja*)	23 to 27%
Linum usitatissimum (lin-seed, *masiná*)	28%
Papaver somniferum (poppy, *postadáná*)	33 to 47 ,,
Amoora rohituka (*pittaraj*)	
Argemone mexicana (Mexican prickly poppy, *Shiálkántá*).	

416. The principal non-drying oils are obtained from the following plants :—

Brassica juncea (*rai*) ...	21 to 28% of oil.
Br. napus (*lutni*) ...	32 to 40 ,, ,,
Br. campestris (*var. sarson*) ...	33 ,, ,,

Br. campestris (*var. toria*)	...	33	% of oil.
Buchanania latifolia (*chironji*)	...	25 to 40	„ „
Cocos nucifera (cocoa-nut)	...	52 to 57	„ „
Sesamum indicum (*til*)	...	45	„ „
Eruca sativa (*tárámani*)	...	12 to 25	„ „
Olea cuspidata (olive, *zaitun*)	...	11·2	„ „
Raphanus sativus (radish)			
Bassia latifolia (*mahua*)	...	27 to 37	„ „

CHAPTER XLVI.

Fibre Crops.

(1) JUTE (CORCHORUS CAPSULARIS AND OLITORIUS).

THE four common varieties of jute, all of which may be found in the wild state in India even in localities where jute is not cultivated (e. g. in the district of Pertapgurh in Oudh, if one looks for the plants there in October), are the Corchorus olitorious (the long cylindrical podded variety), the Corchorus capsularis (the round capsuled variety), the C. acutangulus (the short and winged podded vareity), and C. antichorus, the *bil-nalita,* which is wild and never cultivated. The C. acutangulus is also rarely cultivated. The first which is more common in Southern Bengal, may be designated *Deshi pát;* the second which is more common in Northern and Eastern Bengal may be designated *Serajgunj pát.*

418. The young leaves, specially of C. capsularis, are eaten as potherb, and the dry leaves, specially of the *Deshi pát* (C. olitorius), as an alterative and febrifuge medicine (*nalita*). The stems after the removal of the fibre are sometimes used for making gun powder charcoal.

419. The jute-cultivating industry is pactically a creation of the British Raj. The first separate mention of jute as an article of export is made in the customs returns for 1828, when only 364 cwt. of this fibre went to Europe. In 1854, the first European factory was established at Rishera near Serampore. Several jute factories for baling of raw jute and manufacture of rope and gunny bags, sprang up round about Calcutta in the course of a few years, until in 1886-87 the exports of raw jute were valued at £4,869,814, and of manufactured jute at £1,149,297. The raw jute trade is thus four times as important as the trade in manufactured jute.

420. The area under jute in Bengal is about 2, 271, 600 acres or 3·52 per cent. of the total cultivated area of the Province. The districts of the Dacca and Rajshahi Divisions produce more than 3 times as much jute as the rest of Bengal. The districts that have each more than 50,000 acres under the crop are :—

District	acres	Percentage of total cultivated area.
Mymensingh.	559,100	17·96 per cent.
Rangpur.	268,200	14·82 ,,
Tippera.	212,000	13·03 ,,
Dacca.	211,200	16·03 ,,
Pabna.	174,500	11·07 ,,
Dinajpur.	107,500	6·29 ,,
Rajshahi.	105,200	8·84 ,,
Bogra.	100,000	14·71 ,,
Faridpur.	85,000	6·02 ,,
Purnea.	75,000	3·57 ,,
Jalpaiguri.	68,200	7·79 ,,

421. Taking 12 maunds of fibre as the average produce per acre, the total outturn of jute in Bengal may be put down at 50,00,000 maunds valued at 7 to 10 crores of rupees. As 75 per cent. of the jute is grown for sale and export, 6 to 8 crores of Rupees per annum represent the reserve or potential food earning capacity of raiyats which may be utilized in

course of time for its legitimate purpose as population increases and greater stress is felt by the cultivator. All non-food crops grown chiefly for sale and export by the cultivator may be looked upon in this light.

422. The cultivation of jute is practically confined to Bengal. In Assam it is grown only in Goalpara. Experiments in growing jute in Madras and Bombay have been unfavorably reported upon and there is not much prospect of competition elsewhere ruining the jute industry of Bengal.

423. *Soil.*—With the exception of rocky, laterite and poor sandy soils, all soils are adapted for jute cultivation. Rich loam, of course, gives the best result. The coarse varieties grow luxuriantly in lowlying lands, but a better quality of fibre is obtained from *Aus* land. Pulses, Tobacco and *Aus* paddy are grown on such lands in rotation. *Dearh* and *chur* lands and islands, also *bil* lands and ordinary *Aman* lands produce more vigorous growth and longer fibre, but the quality of the fibre is poorer. An excess of salt (such as occurs in the Sunderban soils) does not injuriously affect the C. Olitorius, though it is not quite suitable for the C. Capsularis. In lands south of Calcutta therefore the C. Olitorius should be grown in preference.

424. In lowlands, *preparation* ought to begin in November or December, though usually the winter cultivation is neglected and the first ploughing given in February or March before sowing. Two ploughings and two cross-ploughings with laddering and one harrowing or collecting of weeds, are a sufficient preparation. The sowing in lands subject to flooding takes place in March, and it goes on to June according to the position of the soil and amount of rainfall. In the *bil* land north of Rajshahi where very heavy outturns are obtained, sowing is done as early as February. One and a half pounds per bigha (*i.e.*, 4 seers per acre) is the quantity of seed used. The ordinary time for harvesting the crop is middle of

August to the middle of September. But jute-washing begins in July in some parts and goes on to the end of November in others. Ten to thirty maunds of fibre are obtained per acre ; but the average may be put down at 12 maunds.

425. The *seed* should be sown by drilling, only 9" apart, so that hoeing with wheel-hoe or bullock-hoe may be done. Hoeing at least once should be done after sowing when the plants are well up, and if possible, one hand-hoeing and one wheel-hoeing or bullock-hoeing should be given at an interval of a fortnight or twenty days between the two operations before the rains set in regularly, when wheel or bullock-hoeing will not be feasible ; or the wheel or bullock-hoeing may be done when the land is not too wet, say, at the end of June, and the weeds pulled up with hand when the rains have set in properly.

426. *Manuring.*—Where there is silt deposit no manuring is required. Elsewhere cowdung at the rate of 150 maunds per acre may be applied where necessary. All fibre crops are appreciably benefited by cowdung manure except those belonging to the leguminous order.

427. The proper time for *harvesting* is when the fruits have just commenced to form. Cut earlier the produce is less and somewhat weak, though whiter and more glossy. Cut later, the fibre is coarser and rougher, though slightly heavier, but it does not do getting a heavier outturn of coarse and dirty fibre.

428. *Steeping* should be done in fairly deep, clear, sweet (not salt) but stagnant water. If steeping is done in running water, a longer time is required for retting, and the fibre is infiltrated with a grey deposit. Salt water also delays the process of retting. Steeped in shallow and dirty water also, the fibre is somewhat grey and it takes longer retting specially if the whole heap is not entirely submerged in water.

429. *Method employed.*—After the plants have been cut, they are left in the field for 2 or 3 days for their leaves to shed. The stalks are then gathered, tied in small bundles and ar-

ranged in heaps of about 2 maunds each, which are covered with leaves and weeds and earth and left in this state for 3 or 4 days. The bundles are then well shaken of leaves, the branching tops being lopped off, and then removed to water where they are kept submerged under a weight of logs or wood, earth and weeds being also used for weighting the bundles. In the hot weather, *i.e.* from July to September, the retting is finished in 10 days to a fortnight. If cold weather sets in it takes longer, sometimes as long as 2 months, in which case some of the fibre gets too much retted, or rotten, and others not rotted enough and the colour of the fibre is grey and the outer bark is not entirely removed from the lower part of the fibre. The submerged bundles should be examined from time to time after a week to see that the stems are not over-retted. Over-retting not only makes the fibres darker in colour but it also weakens them. When the retting is complete bundle after bundle is taken by a man going down into water and the lower end of the bundle is battered with a flat stick or mallet usually made out of palm-leaf midrib. The pith-sticks of the lower end are separated from the fibre by shaking them out in water. The man then takes hold of the bundle of fibres and by alternate pushing and pulling with a jerky motion the whole of the fibre out of the bundle is drawn out. Each bundle of fibres is rinsed and washed, the excess water wrung out from it and it is then opened out in long strands and hung up in the sun to get dry. Another plan is to break off the bundle against the knee in the middle (a smaller bundle which can be conveniently broken being taken) to shake off the portions of the pith stalks at the thicker end, to wrap the fibres from these portions round the palm of the right hand and then pull and push the rest of the stalks as before, in water, until all the fibres are removed. Instead of merely rinsing and wringing the fibres clean, it is better to wash them cleaner by taking larger handfuls at a time and swinging them round the head and dashing them

repeatedly against the surface of the water, until the impurities are washed out. After exposing the fibres for 2 or 3 days in the sun they should be tied in bales and got ready for sale.

430. The *cost of cultivation* inclusive of manure comes to about Rs. 30 per acre. The outturn when so much money is spent, ought to come to 15 maunds per acre, which at Rs. 4 per maund, would bring a net profit of Rs. 30 per acre.

Chemistry of jute.—Jute may be called a ligno-cellulose, standing midway between cotton which is almost pure cellulose and lignose of woody fibre. Good qualities of jute have the following composition :—

Cellulose	64	to	70	per cent.
Pectose matters	24	to	28	,,
Mineral matter	0·2	to	2	,,
Fat and wax	0·4	to	0·8	,,
Extractive matter	1	to	2	,,

431. The proportion of cellulose in jute is much less than in cotton. In fact, jute-fibre when young is richer in cellulose but gradually by loss of water and CO_2 cellulose becomes partly converted into lignose. Like cotton, jute can be dissolved by a concentrated solution of zinc chloride by a mixture of zinc chloride and hydrochloric acid. By dilution and acidification of these solutions, the fibre is precipitated as a gelatinous hydrate to the extent of 75 to 80 per cent. of the original fibre when the solution is fresh. It is important to distinguish between jute and cotton as jute cloths are now commonly sold in the market. Chlorine combines readily with jute, the latter taking up 15 to 16 per cent. of this element. If the Chlorinated fibre be treated with a solution of Sodium Sulphite, a Magenta red colour is obtained, which is characteristic only of jute fibre. To distinguish jute from flax and hemp, an aqueous solution of iodine should be used. Jute is coloured deep brown, while flax and hemp are coloured blue or violet. Jute absorbs acids and alkalis from

solutions, much more readily than cotton, and it is therefore not such a lasting fibre as cotton. If the alkaline treatment is carried on at high temperatures (as in the *Dhobis'* boiler) the non-cellulose constituents of the jute are attacked and converted into soluble products, the fibre finally getting disintegrated.

CHAPTER XLVII.

Fibre-crops,—*continued.*

(2) BOMBAY HEMP (HIBISCUS CANNABINUS)

BOMBAY hemp, Ambari hemp, or Deccan hemp, called in Bengal *Mesta-pát* and in Bihar *Pattuá*, is grown largely as a crop and as a hedge-plant, in Madras, the Central Provinces and Bombay. It is also grown to a certain extent in the N.-W. P., Oudh and the Punjab. In Bengal, it is grown chiefly in Chutia-Nagpur. The merits of this fibre have not hitherto been recognised as they deserve, by exporters. It is superior to jute in every respect and its cultivation should be encouraged wherever possible. The lower part of the steam contains the best fibre and as much as possible of this should be secured in harvesting. It is not only used as a substitute for jute but also for making fishing nets and paper. The pulp for making paper out of *mesta pát* is made by adding 6 seers of lime and a maund of clean water to every maund of fibre. Slips of sized paper weighing 39 grains made from maize stalk pulp, jute pulp and *mesta pát* pulp, bore respectively the weights of 47 lbs., 60 lbs. and

71 lbs., which show the superiority of the *mesta pát* as an article for the paper manufacturing industry. The length of the fibre is 5 to 10 ft. as in the case of jute. The best *i.e.* strongest and glossiest, fibre is obtained when the plant is in flower, and not as in the case of Jute, Crotolaria Juncea, and Abroma Augusta, when it is just in fruit. Jute contains 76 per cent. of cellulose, *mesta pát* 73 per cent., *noná* fibre 62·3 per cent., plantain fibre 64·6 per cent., Sunn-hemp 83 per cent. and Sida fibre as much as 83·8 per cent. Though in respect of cellulose it is not equal to the best fibres, in point of strength it is almost as good as Sunn-hemp and it is much glossier than jute and stronger. The following facts illustrate the strength of the *mesta pát* fibre :—

(*a*) A line prepared from *mesta pát* fibre obtained from plants cut when in blossom and steeped immediately, sustained the weight of 133 lbs. when wet and 115 lbs. when dry.

(*b*) A line prepared from *mesta pát* fibre obtained from plants cut when the seed was ripe, sustained a weight of 118 lbs. when wet and 110 lbs. when dry.

(*c*) A line prepared from *sunn-hemp* fibre obtained from plants cut when in flower sustained a weight of 185 lbs. when wet and 130 lbs. when dry.

(*d*) A line prepared from *sunn-hemp* fibre obtained from plants cut when in fruit sustained a weight of 209 lbs. when wet and 160 lbs. when dry.

433. Rocky and laterite soils which are not suitable for jute cultivation are well adapted for the cultivation of *mesta pát* and areas that are not considered suitable for growing ordinary jute may be well utilized in growing *mesta pát*, while it should be also noted that lowlying lands which are flooded, are not suitable for this crop, though jute may be grown in them. The yield of this fibre is about the same as that of jute and the fibre is extracted even more easily than jute fibre.

434. The young leaves of this plant are eaten as a pot-

herb and the seeds, which are rich in oil, make a good cattle-food and are so used in Poona.

435. All the remarks regarding the cultivation of the jute crop apply to this crop also. The extension of the cultivation of this crop is an important measure of agricultural improvement. Mr. Benson, Manager of the Shalimar Rope Works, who buys the *mesta pát* grown at the Sibpur Farm, speaks highly of it and he pays a higher price for it than for jute. The yield of *mestá pát* at Sibpur came to 15' maunds per acre in 1898.

CHAPTER XLVIII.

Fibre crops—*continued.*

(3) SUNN-HEMP (CROTOLARIA JUNCEA).

THIS is the ordinary *sunn*, but not the true hemp, or Cannabis sativa, of commerce. Hibiscus cannabinus is also called *sunn* or Bombay hemp. The Cannabis sativa or *bhang* plant is found in the wild state in most parts of India, but the fibre is rarely extracted from the wild or cultivated hemp plant, except by some hill tribes. In fact, the hemp plant does not produce a valuable fibre in the plains of India. The *sunn* of India is either Crotolaria Juncea or Hibiscus cannabinus. That Hibiscus cannabinus is classed in the Indian markets sometimes with jute and sometimes with *sunn*-hemp, shows also the greater value of this article than of ordinary jute. The true hemp plant, producing *ganja* and *siddhi*, is an excisable article and its cultivation is prohibited by law. This may also account for the non recognition of true hemp as a fibre-yielding crop in India.

437. The seed of the Indian *sunn* (Crotolaria Juncea) is sown very thick from the 15th April to 15th June. The plant flowers in August, but it should not be cut till September when the seeds have properly formed. It is not a profitable crop to grow in the ordinary lowlying districts of Bengal. Clay soil, rich soils and low damp soils, give vigorous growth but poor yield of a coarser fibre. High and light soils and raviny soils are better suited for this crop. As a leguminous crop, *sunn*-hemp is recognised even by cultivators as a renovator of soils and it is a good preparation, to grow this before a *rabi* crop especially before sugarcane, tobacco, potato or some such rich crop. It is sometimes ploughed in, in young state, as a green manure, by cultivators.

438. In rough or sandy soil very little tillage is required for the crop. Two ploughings followed by one laddering is a sufficient preparation for sowing. The seed should be drilled $6'' \times 4''$ apart, that is thicker than in the case of jute and *mesta pát*. 12 to 15 lbs. of seed per acre will be found sufficient if the seed is drilled. If sown broad-cast, it is best to use half a maund of seed per acre.

439. The steeping of *sunn* stalks is sometimes done exactly in the same way as that of jute stalks, but in dry regions, the plants are sometimes left to dry in the fields after they are cut and the steeping done afterwards. In Lower Bengal, however, the climate is too moist, and dry stacking would spoil the fibre. The yield of fibre per acre is 200 to 1200 lbs.; the average being about 640 lbs. (8 maunds), worth about Rs 50.

440. There is some difference of opinion as to when *Sunn* plants should be cut, whether in flower, or in fruit, or when the fruits are ripe. Every system has its supporter and practice varies. Experiments conducted in different regions can alone decide the point. There is difference of opinion also as regards the best method of extracting the fibre. Various systems are followed :—(1) the stems are buried in some

places in mud in the margin of tanks ; (2) In other places, they are submerged in water and weighted like jute. (3) In some places running water is chosen and in others stagnant water. (4) In dry regions the stems are tied in bundles of 20 to 100 and left on the field until they are quite dry. After 2 days' steeping in water, the fibres are easily detached. (5) Separation is also effected without retting. When steeped like jute, 4 days' to a week's steeping is sufficient in the hot weather and oversteeping must be avoided. When retting is complete, bundle after bundle is taken and threshed in water until the fibre separates out. The drying of bundles of *Sunn* is done in the same way as drying of jute fibre ; but heckling is afterwards required to get clean fibres parallel to one another. One third of the weight of the fibre is lost in this heckling process, but the tow obtained is a useful material for making paper.

441. The seed of *Sunn* hemp used as fodder increases the flow of milk of milch cows.

CHAPTER XLIX.

Fibre-crops—*continued.*

(4) RHEA (BŒHMERIA NIVEA, &c.).

THIS crop is also known as Ramie, China-grass, and Kankuṛá. Inordinate hopes are raised from time to time regarding the prospects of the rhea-planting industry, but there is little hope of its being worked with profit in this country, except with very expensive European machinery. The hand-stripping of ribbons or bark, as practised in China and in this country is very expensive. The crudely cleaned

and unbleached fibre, used by the Burmese, Assamese, Nagas and by the people of Rangpur, Jalpaiguri, Bogra, Dinajpur, Purneah, and Bhagalpur, for making fishing lines and nets, is raised by a few cultivators only, each on a few square yards of land. But in none of these districts could the raw firbe be procured for less than 8 annas a seer; and if any considerable quantity is wanted from any of these districts, the raw article would not be forthcoming for less than Rs. 50 to Rs. 100 per maund. A decorticating machine could no doubt render the raw produce cheap, and there are now several of these claiming public favour, but more extensive trial is needed before one can say definitely, that the rhea-cultivating industry can be made profitable. £20 or even £40 a ton for the raw hand-stripped ribbons is not a sufficiently remunerative price for this article, and though such prices are being offered for some years, practically no rhea ribbons have been exported into Europe. Besides it is a mistake to suppose that rhea will grow anywhere and under any conditions and that crop after crop can be taken in any soil without manure. It is no doubt a perennial, but it grows best in shade, on rich loam and the land must be above inundation level, but at the same time sufficiently moist to keep the plants in vigour. The crop luxuriates in fact only on the best tobacco soils of Rungpur. But even in Rungpur, the crop is of so little importance, that the village called Kankurapara (named after this crop) and where only the crop is considered of any importance, has only about 20 cultivators growing it.

443. In Bogra the ribbons stripped from the stems are boiled in turmeric water for a few minutes or in water in which rice has been boiled. This operation softens the fibre and assists in the subsequent cleaning process. In Bhagalpur the green stems divested of leaves are boiled in water with the addition of 10 chhitaks of *saji* per maund of plant put in the boiler, and the whole allowed to simmer or boil for 1½ to

2 hours. Bundles of boiled stems are afterwards dashed on a board, first one end then the other, until all the pith is removed. The fibre is again boiled for half an hour in the original liquor and then again beaten and washed on the board which is arranged like a *dhobie's* board by the side of water.

444. Scraping of the outer bark or parenchyma is practised in most districts, before the fibre is hand-stripped. In Assam after the leaves have been stripped off a stem, it is divested of the outer skin by rubbing it with a blunt knife, after which the stem is left to dry for 2 or 3 days in the hot sun. The third morning after the stem has been exposed to dew for several hours the fibre is drawn off the stem by breaking the woody stalk right through towards the thicker end and then separating the fibre therefrom by drawing it off gently towards the slender end, some care being required in giving the fibre the peculiar twist in order to draw it off without breaking. A good deal of the fibre (about $\frac{1}{3}$th) remains adhering to the stem after the drawing off has been done as described.

445. A maund of green stems produces about a seer of fairly white fibre treated in this way *i.e.*, only $2\frac{1}{2}$ per cent. Seven to eight maunds of fibre may be obtained per acre per annum, but the separation of the fibre from the stems is so difficult and costly that cultivators actually go in for cultivating a few square yards and no deductions as to cost and outturn can be definitely drawn with regard to this fibre from the data they are able to furnish. Others estimate the produce at as much as 50 to 55 maunds per acre.

446. In Spain and other European and American countries where rhea is grown and where machinery is used for the extraction of fibre, 500 acres of a properly managed plantation is estimated to produce 7000 to 9000 tons of green stems per annum, out of which 3 per cent. of fibre is obtained, which is equivalent to 1792 lbs. of fibre per acre per annum. The average weight of 100 stems of full grown rhea without

leaves is about 24 lbs. The Chinese grow about 80,000 stems per acre *i.e.*, about 19,200 lbs. Faure's decorticating machine which extracts 3 per cent. of fibre which is in a purer state than China-grass, yields 576 lbs. of fibre in one cutting. In the remaining two cuttings another 576 lbs. at least may be reasonably expected, or a total of 1152 lbs. per acre per annum, which at £30 per ton (the price paid in London for high class 'China-grass') is worth about £15, or Rs. 225, while an acre of indigo produces a gross outturn of only about Rs. 20 or Rs. 30. From the Spanish and Chinese figures it seems, one may fairly estimate the produce of rhea fibre at 1000 lbs. or say 12 maunds per acre per annum, which is a more reliable figure to go upon than either 7 to 8 maunds or 50 to 55 maunds per acre, which are the figures variously given by Bengal cultivators. Of course, the climate has everything to do with the produce. Where the climate is damp, and the soil always more or less damp, without ever getting water-logged, 25 maunds of fibre may be obtained, while in dry localities the produce may not reach even 5 maunds to the acre.

447. *Method of cultivation.*—Rhea is propagated from stem-cuttings and root-cuttings, also from seed. The cuttings 6″ to 9″ long may be planted horizontally 3″ to 4″ under soil 1 ft. apart each way. 12,000 to 13,000 cuttings are required to plant an acre. The fields should be weeded and hoed after each cutting of stems and heavily manured each year during the dry season. Blanks should be filled in from time to time by planting cuttings horizontally 3″ deep as already mentioned. The shoots are cut down when the bottom portion of the stem begins to turn brown and the leaves low down the stem begin to fall off. Two to five cuttings are obtained annually according to the richness of the soil and the care with which the plants are tended, three cuttings being a good average crop. Six cuttings can be obtained in shade, if the plants are heavily manured and watered. If

stems ready for cutting are alone selected, as is the practice with some intelligent cultivators, cuttings can be had uninterruptedly throughout the year. If the cuttings are first planted in September, the first crop may be harvested in May (which is the shortest crop), the second in June (the best crop), the third in July and the fourth in August. Planting of cuttings can take place in May and June also.

448. If rhea is *propagated from seed*, it is necessary to sow the seed superficially on light sandy soil well manured with rotten dung. Rhea seed like sugarcane seed should not be covered with earth after sowing. Even a light covering of earth prevents germination. But on the seed-bed there should be a covering of mat put on as is done in sowing cabbage and cauliflower seed. This mat should be kept moist and the seed should not be watered direct. When plants have fully appeared, the covering of mat should be taken off, and watering done occasionally as required. September is the best time for sowing and transplanting rhea. The seedlings should be transplanted when they are about 3 inches high.

449. The question of the *extraction of fibre* from the stems is so important, that the Government of India offered at one time a reward of £5,000 for a rhea fibre-extracting machine, but this offer was withdrawn by a Resolution dated 19th March 1881. This Resolution says: "From the low valuation put by the English firms on the samples of fibre produced at the late competition, it does not seem probable that Indian rhea fibre will be able, for the present at least, to compete successfully with the Chinese product; while the experience which has been so far gained also points to the conclusion that in most parts of India the cultivation of rhea cannot be undertaken with profit. Rhea is naturally an equatorial plant, and it requires a moist air and rich soil and plenty of water, while extremes of temperature are unfavourable to it. Such conditions may be found in parts of Burma, in Upper Assam,

and in some districts of Eastern and Northern Bengal, and if rhea can be grown in such places with only so much care as is required in an ordinary well farmed field for a rather superior crop, it is possible that it may succeed commercially. Until however private enterprise has shown that the cultivation of the plant can be undertaken with profit in these or other parts of the country, and that a real need has arisen for an improved method of preparing the fibre in order to stimulate its production, the Government of India think it inadvisable to renew the offer, which it has now made for the second time without result, of rewards for suitable machines."

450. It is difficult to say whether the inventions lately made of machinery for decorticating and degumming the rhea fibre will really prove so valuable as they claim to be; but from all accounts it seems there have been some very good machines invented of late. The inventions which should be prominently mentioned are those of M. Faure, Mr. Gomess, also of Messrs. Macdonald, Boyle and Co. of 39, Victoria Street, Westminster, London, S. W. and of Mr. Charles J. Dear of 28, Victoria Street, Westminster.

451. Messrs. Macdonald, Boyle & Co. recommend two sets of decorticating battery, each set comprising of 40 drums for a plantation of 400 acres. Their estimate is given below :—

	£
Two batteries of decorticators including engine and boilers	1200
One degumming plant including fittings	500
Engine and boilers for Do.	400
Soaking, chemical and water tanks	250
Steam barrel, steam valves and fittings	15
Steam pump and appliances	100
Belting	50
Weighing and baling machinery	300
Freight and sundries	185
Total	£ 3,000

452. This estimate does not include the cost of erecting buildings and sheds. They estimate the daily outturn from the factory at 2 tons of clean and dry filasse. In the English market the value of this filasse is about £40 per ton, and the annual gross outturn from the factory may be put down at nearly 4 lakhs of Rupees. An estimate of cost of producing 1 ton of filasse is given below :—

	Rs.
Cost of cultivation including harvesting (at 1 coolie per 3 acres) of 40 tons of stalks the produce of about ½ an acre	25
Cost of decorticating the 40 tons of stalks by the Macdonald process	20
Cost of degumming the fibre from the 40 tons of stalks inclusive of the cost of chemicals	36
Supervision	10
Freight of 1 ton of filasse including sacks for baling ...	38
Brokerage and landing charges	12
	141

453. If as much as Rs. 600 per ton (over Rs. 20 per mnd.) can be had for the filasse in the London market the net profit may come to as much as Rs. 450 per ton. If a capital outlay of 2 lakhs of Rupees is incurred in the purchase of 400 acres of land and in building and furnishing the necessary plant and if 300 acres out of the 400 are actually under rhea (the remaining 100 acres being taken of by paths, buildings &c.), the net outturn from the plantation and factory may be put down at 2,62,500 Rupees per annum, or over cent. per cent. But an experiment of such a magnitude can be tried only by a millionaire or by a joint stock company.

454. Mr. Dear's process aims at decorticating the fresh cut stems on the plantations and degumming the crude fibre in England, where, in Yorkshire, Mr. Dear has equipped a factory to turn out per day 600 to 1000 lbs. of fibre ready for

spinning, at a cost of only £1,000, exclusive of the motive power but inclusive of the installation of electric light. The supply of crude fibre comes to him from China. Mr. Dear claims that his decorticating machine will extract any kind of fibre and that the cost of the machinery is so moderate that the chief obstacle in the way of the ramie manufacturing industry is removed. We have as yet no further information regarding this interesting invention, though Messrs. Burn & Co. of Howrah, are in possession of the plant and they may be consulted on the subject.

455. Faure's New Patent Ramie Fibre Decorticator is also highly spoken of. Messrs. Jules, Karpelès & Co. of No. 1, Pollock Street, Calcutta, who are the agents for this machine, have demonstrated from time to time the use of one of the hand-machines at their office, and we can speak of its usefulness with more confidence. The following account of it appeared in the Planter of the 25th March 1899 :—

"Two men working this machine can treat 360 lbs. of fresh green stems per hour or 32 cwts. per day of 10 hours. The amount of dry fibre produced varies with the quality of the stems but on a basis of 5% comes to about 180 lbs. per day of 10 hours. The machine produces fibre, not ribbons. Each machine requires about 1 H. P. to drive it; 8 H. P. will drive ten machines working simultaneously. The fibre as it comes from the machine is steeped in boiling water, with the addition of 1% of carbonate of soda for about half an hour and squeezed thoroughly before drying. The machine weighs 11 cwts. It is fed by two men, working alternately, each holding in his hand about 10 stems. The stems are used with leaf and all the leaf end is put in first, and when two thirds of the length of the stems have gone in, they are withdrawn and the feeding is done a second time, the thick-end first, so as to complete the operation. This double operation frees the stem from all woody matter and from the outer skin or cuticle and extracts a large portion of the juice also." As far as our

observation went, the produce of dry fibre from this machine ought to be put down at 50 lbs. rather than 180 lbs. *per diem.*

456. The products of the Gomess process, which is a chemical process for treating the ribbons, can be seen illustrated in the Economic Section of the Indian Museum.

457. M. C. N. Reviere, the French Government Botanist at Algiers, states that the Ramie linen supplied to the steamers of the Compagnie Transatlantique was in good condition after 90 voyages, while ordinary linen was worn out in 45 trips. There seems little doubt as to the lasting qualities of ramie, and this, in addition to its silky character, would make it a highly valuable textile product if it could be introduced as an agricultural and commercial article of the country.

458. The prospect of Villebrunia integrifolia or Ban-Riba, a wild fibre plant of Assam, which, like rhea, belongs to the nettle family, seems much better than that of rhea. It has little or no gum and it gives a good return even in soils where rhea fails. The fibre is very fine and as strong as that of rhea. It is a tree which is found in the wild state both in Assam and in Ceylon. It grows about 20 feet high.

459. The fibre of a stinging nettle, Girardinia heterophylla, the leaves of which resemble those of grape vines, is extracted and used by the Napalese. This nettle grows to a height of about 10 feet in the Nepal terai.

CHAPTER L.

Fibre-crops—*continued.*

(5) COTTON (GOSSYPIUM).

THERE is considerable difference of opinion as to the botanical characters which distinguish Indian cottons. Cottons are probably referable to three main classes :—(1) the tree cotton (Gossypium arboreum); (2) the American cotton

(G. Barbadense) and (3) the herbaceous cotton (G. herbaceum). The G. arboreum has its leaves more or less hairy, $\frac{3}{4}$ segmented or almost cut to the base, generally into 5 lobes. Flowers purple, or purple with yellow centre, rarely white; seeds free from each other, covered with white cotton overlying a dense green or blackish down; lint difficult to separate from the seed. A supplementary tooth on one or both sides of the middle lobe of the leaf forms a most peculiar character which readily distinguishes it from G. herbaceum. The G. arboreum is in flower during the greater part of the year and it sometimes goes on bearing for 5 or 6 years. It grows on every kind of soil, but it prefers high, light, sandy soils. The lint is fine, silky, strong and fully an inch long. The yield of lint in the first year is about 100 lbs. per acre, and in the 2nd and 3rd years 300 to 400 lbs., after which the yield falls off. The Burhi Kapas, Narma cotton, Ram Kapas, and Deo Kapas, belong to this class. It is rarely grown as a field-crop. In fact, there is prejudice in some districts against its cultivation except by Brahmins. A stunted variety of this, called G. neglectum is, however, extensively cultivated as a field-crop. It has bright yellow flowers and deeply palmate leaves which in shape are scarcely distinguishable from those of G. arboreum proper, except in that they are more herbaceous and very much more hairy. The superior white cottons of Eastern Bengal and of Northern India are mostly G. neglectum. The long bolled Garo-hill cotton belongs to this class also. The Burhi cotton of Manbhum grown on rich land in gardens and homesteads only, is G. arboreum proper, while the Bhoga cotton which is the ordinary field cotton of the district is G. neglectum. The former flowers in November and yields a larger crop. The Bhoga sown in June and July flowers earlier in October, attains only a height of 2 or 4 ft. and yields a smaller outturn. The Sheraj, Borailli and Tangori cottons of Dacca also belong to G. arboreum.

461. The yellow flowered G. barbadense (Egyptian and American cotton) grows better on clay soils and in moister regions. It benefits very much by free irrigation, while the G. arboreum requires no irrigation and grows better on high, dry and sandy soils. The G. barbadense is supposed to have its origin in America and the G. arboreum in Africa. The G. barbadense has more entire leaves, the upper leaves being only angled, and the lower ones being 3 to 5 lobed, and the lobes never supplied with supplementary teeth. The Kidney or Peruvian cotton is quite distinct from the other forms of American cotton such as the Sea Island, Georgian and Bourbon. The Kidney cotton has its leaves more deeply segmented and the seeds have the peculiar character by cohering together in a Kidney shaped mass.

462. Another variety of cotton should be here mentioned, viz. the Nankin cotton, which has usually Khaki or light brown lint. This belongs to G. religiosum, Linn., which is probably hybrid between the G. arboreum and G. herbaceum. The white flossed G. religiosum of cultivation is a good variety.

463. The Egyptian cotton seems to be derived from G. barbadense, variety hirsutum, which in its turn is probably derived from the Sea Island variety of American cotton which is G. barbadense, viz. maritinum. The Sea-island and Egyptian cottons are both adapted for cultivation in the delta of the Ganges. The Bamia cotton of Egypt which has been successfully grown in India and is a hybrid between G. hirsutum and G. maritinum has lint with a tinge of brown. This variety requires more irrigation than other varieties. G. Barbadense (or Bourbon cotton) is a perennial American cotton grown as fence, or in gardens, the cultivated variety of which is G. maritinum. This variety also has been introduced with success into India. The seeds of G. barbadense are not velvety like those of Indian cottons but smooth and naked, the lint being easily separated from them.

464. The G. herbaceum is a truly Asiatic cotton and it is

cultivated in N.W. India, Egypt, Northern Africa, Asia Minor and Southern Europe. It is perennial and bushy in the warmer areas, and annual where the cold weather being severe kills the plants. The stems are erect, branches spreading. Leaves pale green, thick, leathery, half segmented into 3, 5 to 7 lobes. Flowers yellow with a large purple patch. Its chief features are its broad leaves, more rounded lobes, the absence of hairs. The seeds are beaked and the cotton inferior. The Khaki coloured cottons belong to G. herbaceum. As the superior Indian cottons with large bolls belong to the G. arboreum and as the still superior Egyptian and American cottons belonging to G. barbadense are being successfully grown in India, we need not deal any further with the G. herbaceum.

465. The relative value of cotton fibre depends mainly on the length of the staple. The Sea-island cotton has its staple 1·65 inches long, the Egyptian 1·50 inches, the Bourbon or ordinary American 1·10 inches and the Indian ·65 to ·90 inch, the latter figure being the average for G. arboreum.

466. Cotton is soluble in strong alkaline solutions. With nitric and sulphuric acids in same proportions, it forms gun-cotton, which dissolved in ether and rectified spirit, produces collodion. It has a strong affinity for alumina, hence the use of alum as mordant in dyeing cotton. Iron stains it yellow which cannot be removed by alkalis or soap unless the stain is quite recent. It has strong affinity for oxide of tin also, which like alum is used as a mordant. Nitric acid and heat decompose cotton wool and form oxalic acid.

467. The stems of the plant if rotted yield good fibre.

468. Indian cotton seed is not so rich in oil as the American cotton seed and this fact should be borne in mind if the extraction of seed for oil from the seed is thought of.

469. In the struggle between America and India in the European cotton market, which has gone on for 100 years, America has gradually supplanted India. In 1818, the export

of Indian cotton to England amounted to as much as 86,555,000 lbs. or 247,300 bales (a bale of cotton = 3½ cwt.). In 1821 only 20,000 bales were exported. In 1841 however the export rose to 278,000 bales. In 1848 the export fell to 49,000 bales. During the American Civil War, India again became the chief source of supply of cotton to the English market. At the end of the War, American cotton regained its footing in the English market. The objections to the Indian cotton in the English market are,—(1) imperfection of picking, cleaning and packing, (2) adulteration, (3) the higher price which has to be paid for the inferior hand-ginned cotton compared with the price paid for the superior machine-ginned American cotton, (4) the shorter-staple of the Indian cotton. The improvement in cotton cultivation in recent years is chiefly due to the establishment of numerous cotton mills in India.

470. The area under cotton in India has been estimated, at about 15,000,000 acres and the outturn of cleaned lint, at about 9,000,000 cwts. Of the 9,00,000 cwt., about 5,00,000 cwt. are exported, 3,00,000 cwt. used in mills in India and 1,00,000 cwt. used in country looms for domestic purposes. The acreage under cotton in Bengal has been estimated at 162,000 and the outturn at 138,800 cwts. or 96 lbs. per acre. Cotton-growing is a minor industry in Bengal.

471. *Arahar*, *til* and *juar* are often grown along with cotton.

472. The time for sowing and picking cotton in the principal cotton-growing districts of Bengal are given below :—

	Sowing time.	Harvest time.
Midnapore ...	May and June.	September to March.
Cuttack ...	(1) June to July,	(1) October and November,
	(2) November and December,	(2) May and June,
	(3) October and November.	(3) February to June.

	Sowing time.	Harvest time.
Manbhum ...	(1) May to July,	(1) October to December,
	(2) September to December.	(2) February to April.
Lohardaga ...	(1) June,	(1) November to January,
	(2) October.	(2) April and May.
Durbhanga ...	(1) May and June,	(1) March and April,
	(2) October.	(2) August and September.
Sarun	June and July.	... April and May.
Chittagong Hill Tracts	(1) April and May ...	(1) Nov. „ Dec.
	(2) Jany. „ Feb. ...	(2) Aug. „ Sep.

According to the above table, March and August are the only months when cotton is not sown and July the only month when picking is not done.

473. On an average, to every 30 parts of cotton there are 20 parts of seed obtained, and the feeding value of 200 lbs. of cotton seed obtained per acre, is at least Rs.5. The profitableness or otherwise of the crop therefore depends mainly on three considerations: (1) the staple chosen, (2) the use of cotton gin, (3) the utilisation of seed as cattle food. One variety would yield 300 to 400 lbs. of lint per acre, whereas another will yield only 75 lbs. On the whole, the Burhi cotton seems to be the best to grow in Bengal, though persistent attempts should be made in growing the superior Sea-island and Egyptian cottons. It should be mentioned that sowing of the Egyptian and American cotton seeds should be done in October instead of in June.

474. The *cost of cultivation* per acre for the cotton crop may be calculated as below :—

4 ploughings before sowing	3	0	0
Manuring with cowdung and lime compost (150 maunds of dung and 4 maunds of lime per acre)	2	8	0
	5	0	0

00

Watering before sowing	2	8	0
Pickling of seed (5 seers) with dilute sulphuric acid and the ordinary pickling powder ...	1	0	0
(or rubbing with cowdung, in which case the cost is almost nothing)			
Cost of sowing behind plough	1	0	0
Watering after sowing	2	8	0
Hoeing and thinning or patching	2	0	0
Picking ($\frac{1}{10}$th of produce)	2	0	0
Rent	3	0	0
Cleaning or ginning (1½ annas per 10 lbs.) ...	1	0	0
	25	8	0

96 lbs. of cotton at 4 as. a lb. can fetch only Rs. 24 and unless a heavy yielding variety of cotton is chosen, cotton-growing does not pay. Ginning usually costs a good deal more than what is calculated above but where the industry is well established poor women do actually work at these low wages.

475. *Silk cotton* or *simul* (Bombax Malabaricum) is a tree. The fibre of this is worthless for textile purposes, and it is used chiefly as padding for pillows. *Akanda* (Calotropis gigantea) pod fibre may be looked upon in the same light. But the fibre obtained from the stems of this plant is one of the strongest fibres known. The stems are cut into sticks about 18 inches long, dried in the sun for 2 or 3 days, battered afterwards and then the outer bark peeled off and the fibre picked out with teeth and fingers from the inner bark, and then twisted into rope for cordage or fishing net. No water is used either for retting or for helping in the twisting of the rope.

CHAPTER LI.

Fibre-crops—*continued.*

(6) ALOE FIBRES.

VARIOUS plants of the natural order Liliaceæ and its allied order Amaryllidaceæ, yield leaves rich in very strong and beautiful fibres. To the former belong Yuccas and Sansivieras and to the latter agaves,—all being popularly classed as aloes.

477. *Yuccas.*—The fibre of yucca gloriosa or *Adam's needle*, which we have at Sibpore, is fine, silky and strong, but the length is so short that this plant cannot compete with Sansivieras, agaves, or pineapple plants. The fibre is not unlike pineapple fibre, but the average length is less than 2 ft.

478. *Sansivieras.*—These produce the celebrated bow-string hemp. This fibre being silky white, is superior to agave fibre, but the length is seldom over 3 ft., while agaves often reach 6 to 7 ft. in length. The wild Sansiviera (S. Zeylanica) of Faridpur and other districts of Bengal (called *Chhunch-mukhi* or *moorva*) produces as good fibre as S. Cylindrica, or S. Guineensis. Of all the Sansivieras, the S. Trifasciata, which is to be commonly seen in Calcutta gardens, grows best, and is on the whole, the best variety to choose. The length which the leaves attain is generally 3 to 4 ft., while the length of the other kinds is generally under 3 ft. The S. Trifasciata does not require so much watering or manuring as the other Sansivieras do. The strength of the Sansiviera fibre compared to some other fibres can be judged from the following figures :—

	weight borne
Line made of cocoa-nut fibre (coir) ...	224 lbs.
„ of Hibiscus cannabinus fibre ...	290 „

		weight borne
Line made of	Sansiviera Zeylanica ...	316 lbs.
„	Gossypium herbaceum ...	346 „
„	Agave lurida	362 „
„	Crotolaria juncea	407 „
„	Calotropis gigantea	552 „

With Faure's machine Sansiviera fibre is extracted in one operation out of the fresh leaves.

479. *Agaves.*—Though coarser than Sansiviera fibre, Agave fibre being stronger, and being produced by plants which seem to grow best on poor droughty soils, is likely to respond better to cultivation operations. There are five distinct commercial plants known as agaves: (1) Agave lurida which is generally grown round jail gardens in Bengal and which is more commonly known as Agave Americana. It is variously called kawá, bilaiti-kiá, kongá, mugái, ánár, nák-pheni, murga, ban-ánáras and morabba. (2) Agave vivipara or Bombay aloe is almost as good as Agave Sisalana or Sisal hemp. Soutar's mill is used very successfully in Bombay for the extraction of this fibre. (3) Agave rigida, variety longifolia the leaves of which are armed at the sides as well as the tips with spines, A. vivipara being armed at the tips only. (4) Agave rigida, variety Sisalana, produces the celebrated Sisal hemp of commerce. (5) Fourcroya gigantea or the Mauritius hemp, which produces fibre as good as the Sisal hemp, and the leaves being usually free from spines both on the sides and on the tips, are easier to work with. The Fourcroya gigantea also grows better on poor soils than the Sisal hemp, and is altogether the best Agave to grow for fibre, though as a hedge plant it is useless. Agave lurida fibre extracted with Faure's machine has recently fetched £24 per ton, and an acre of land may safely be relied upon to yield 10 maunds of agave fibre per annum. Agave Sisalana fibre recently fetched as much as £36 per ton in the London market.

480. The general rules to be observed in planting all agaves are: (1) Plant about 400 suckers to the acre,—8 feet between rows and 6ft. between plant to plant. If a smooth edged variety is chosen plant closer, *i.e.*, 800 to the acre. (2) Whenever a leaf assumes the horizontal position cut it out for extraction of fibre. (3) The cutting out of leaves generally commences from the fourth year after planting and it goes on until the plant flowers which it does in 7 to 15 years. (4) All suckers should be removed from the bases of plants as soon as they appear as they weaken the main plant. They may be planted in a separate nursery to be afterwards transplanted into the field. (5) Planting of suckers between the older plants for renewing the plantation should commence as soon as leaves begin to be cut, that the plantation may be always in full bearing. (6) Each plant after 4 or 5 years should be divested only of 25 to 35 leaves per annum, a quantity which will yield 1 lb. to 1½ lbs. of clean fibre. If 800 plants are planted per acre as much as 1200 lbs. of clean fibre can, therefore, be obtained per acre. (7) The leaves should be made into bundles of 50, and each labourer should produce daily 30 such bundles. (8) Rich, moist good soils should not be chosen for growing agaves, as such soils are only wasted on this crop. The growth is luxuriant, but the fibre on such soils is weak, and if there is water-logging the plants perish.

481. *The Indian aloe.*—The fibre of the common Indian aloe (Agave lurida) being strong and not subject to the attack of white-ants, is largely used for cordage, house-mats &c., and in London the fibre fetches £20 to £30 per ton. In Mauritius where the soil is getting exhausted by continuous cropping with sugarcane, agave planting has been introduced as a new and profitable industry. What is known as "Mauritius hemp" is the fibre of an aloe (Fourcroya gigantea). The ordinary Indian aloes grow on the most arid soils and unless water-logging takes place it grows anywhere without trouble. The planting is done 5 or 6 feet

apart. When 7 or 8 years old the cutting of the plants begins, suckers being in the meantime planted in between the original plants. The plant can be propagated from seed also, sowing being done in the rainy season. Transplanting should be done after a year on ridges. After the flowering stalk has appeared the leaves should be at once used for extraction of fibre. Before this period the fibre is weak. After 7 years the plant will yield about 10 maunds of fibre per acre per annum (from 50 maunds of leaves). No irrigation or manuring or weeding is required and all the care necessary after planting must be devoted to the extraction of the fibre from the leaves. A machine similar to the sugarcane crushing machine should be used for crushing out the juice and breaking the outer parenchyma. The crushed leaves are then pounded on smooth stones with wooden mallets until all the cellular and woody matter are separated, by washing the fibre in an adjoining running pool of water alongside of which the beating operation should take place. The fibre is then dried in the sun and exported or used. For paper-making purpose it has been found to be a very valuable material.

482. *The Mauritius hemp.*—The variety of aloes grown in Mauritius is the green or fœtid aloe (Fourcroya gigantea). This plant is now cultivated in parts of Ceylon and India. In German East Africa also the Mauritius hemp and hemp-extracting machine have been introduced. Any poor and dry land suits it. Gravelly soil produces the best fibre. Moist and rich lands are not suitable. In fact the plant flourishes best where ordinary vegetation does not cover the land. The leaves are 4 to 7 feet long, 4 to 6 inches broad at the middle, bright green in colour and either armed with small black marginal spines or altogether smooth. The pulp when the leaves are crushed gives off strong pungent odour. Planting should be done in the open in the rainy season. The plant reaching maturity, a flower stalk 15 to 20 ft. in height grows out from its centre. The blossoms form into bulbels

that develope into young plants. Thus it goes on propagating itself.

483. *The Yucatan aloe* or Sisal hemp is almost as good as the Mauritius hemp. The machine used in Yucatan (Mexico) for the extraction of the fibre is Solis's Raspador, which, owing to its simplicity, strength and cheapness, seems to be admirably adapted for extraction of agave fibres in this country where the management of complicated machinery in country places give great trouble. 9,000 leaves are cleaned by this machine in a day of ten hours. Two men are needed to work it, and an engine of 6 H. P. The cost of this machine in the United States is 120 dollars, exclusive of the steam engine. Two such machines can be worked with a 12 H. P. engine in a plantation of 100 acres. The Raspador is a large toothed wheel which scrapes the pulp off the leaves in the same way as the gratte scrapes the pulp out of Mauritius hemp. It is most economical to grow the Sisal hemp like other agaves on dry rocky soils. The growth on rich alluvial soils is more vigorous, but the fibre is poorer. If suckers 18″ high are planted, in 5 years the leaves will be ready for cutting and the plantation will go on yielding for 20 years. It is best to set fire to jungle land, give it a rough cultivation, sow maize and the suckers of the agave at the same time, say in May, in alternate lines. The crop of maize will pay for the planting of Sisal hemp. Then, however, there is the waiting for 4 years, when two weedings should be given to keep the plants in condition. A leaf should be cut off when it assumes the horizontal position. A full grown plant yields annually about 20 leaves. 1,000 leaves produce about 50 lbs. of clean fibre and one ton of green leaves give about 80 lbs. of fibre. When a plant sends up a flower-stalk it should be removed to allow young suckers growing underneath to come up more vigorously. 700 to 800 plants should go to the acre; and half a ton of fibre per acre may be taken as the annual produce, a quantity obtained from 14 tons of green leaves.

The price of the fibre in London is about £35 per ton. A plantation lasts for about 20 years after which fresh planting becomes necessary.

484. *Machinery employed.*—Faure's machine, adapted for rhea, sansiviera and agaves, has been already alluded to. It costs Rs. 1,000 per set. Silburn's Agave-extracting machine, costing Rs. 819, is worked with steam-power. It is capable of keeping an 100 acre plantation at full work, the produce per acre being 10 maunds of fibre per annum. 90 per cent of the weight of leaves gets rejected in the form of pulp. This is used mixed up with farmyard manure in Mauritius for sugarcane plantations. In Mauritius the machine employed is known as the Gratte which consists of a drum 2 feet in diameter and 1 foot wide. On the circumference of this are bolted 2 inch L-shaped blades parallel to the axis. These blades are generally of iron, but steel is preferred. They are firmly fixed to the drum by means of bolts and nuts. The drum is mounted upon an axle and made to revolve with great rapidity close to and against the front or edge of a feed-table. The feed-table is adjusted by means of screws so as to approach the revolving drum within a distance of a quarter inch to an inch as required. It consists of a stout brass plate or lip fitted firmly to a piece of hard wood by means of a bolt. The plate and wood are themselves fixed to two wooden bars 6 inches × 6 inches which serve as guides in the movement of the feed-table backwards and forwards. The most difficult task in connection with the working of the gratte is the exact adjustment of the feed-table inmediately before the machine is started. Once adjusted properly it should be kept in the position for 8 to 15 days when a re-adjustment will be found necessary. The machine is generally mounted in pairs on the same axle and driven by steam or water-power. The cost including driving pulley, bolts &c, is about Rs. 250 per gratte or drum. The H. P. required to drive one gratte is 3.

The weight of each gratte is about 4 cwt. and the outturn per day 2½ maunds of dry fibre. Faure's machine is only a modified form of gratte.

CHAPTER LII.

OTHER FIBRE CROPS.

ABROMA Augusta (ulat-kambal) :—It is a perennial bush or small tree, the stems of which yield a valuable silky fibre. The stems can be cut three times in the year and as the retting and extraction of fibre can be done as in the case of jute, it is very desirable to introduce this crop rather than rhea as a high class perennial fibre crop. It flowers in the rainy season and the seed ripens in the cold season. Roxburgh says that the fibre of *ulat kambal* is one-tenth part stronger than *sunn* and much more durable in water.

486. *Hibiscus abelmoschus* (*kasturi*).—Nearly all malvaceous plants yield useful fibres. The common H. Esculentus or Ladies' finger, the Roselle (H. Sabdariffa), the H. Mutabilis (*Sthal-padma*), H. Rosasivensis (*Jaba*), and H. Ficulneus (*Ban-dhenras* or *Belun-pat*), have been all used for their valuable fibre. Indeed the last named plant is preferred to jute by the cultivators of Murshidabad for their own domestic use. In an experiment conducted by the Agri-Horticultural Society of India, H. Abelmoschus yielded the best crop of all the fibre-yielding plants experimented with, and the yield came to 800 lbs. of fibre per acre, with a Death and Ellwood's machine, while a larger yield (12½ maunds per acre) was obtained by the ordinary process of retting. The seed also has a commercial value and it is known to perfumery makers in Europe by the name of *grains d'ambrette*. The seed when ground gives

the smell of musk and amber and it is used for making sachet-powder and perfumery.

487. Of other fibre-yielding plants the following may be mentioned :—

Ananas sativa.

Musa paradissica (Banana and plantain stalks).

Musa textiles (Manilla hemp).

Pandanus Utilissimus (*Keyaphul*).

Sesbania Ægiptiaca (*Jainti*).

S. Aculeata (*Dhaincha*).

Passiflora Sp. (*Jhumkalata*).

Anona reticulata (bullock's heart).

Sida rhomboidea (*Berela*).

Saccharum Ciliare (*munj*).

Ischœmum angustifolium (the *Bhabur* or *Babui* grass which is largely used for paper-making).

488. The "Quaxima" fibre of Rio-de-Janeiro being considered one of the coming rivals of jute may be also mentioned here. The fibre is long and strong and it can resist the action of water. The plant grows in low-lands near the sea. Of fine linen-like fibres may be mentioned the "Ibira" fibre of Paraguay.

CHAPTER LIII.

PINEAPPLE (ANANAS SATIVA).

PINEAPPLE plants should be guarded against excessive heat and cold; that is why they are grown under shade. They do best on low, rich land that will not overflow, and near water. High land if moist is suitable. In Florida they are planted 18 to 24 inches apart in pineries, *i.e.*, under *mácháns*.

As many as 20,000 plants (planted 2 ft. × 1 ft. apart) are crammed into an acre in the Bahamas islands whence the fruits are largely exported to the United States. The ground chosen in these islands is more or less rocky. The owners of land share with the cultivators in the produce. The proprietors of land make advances in cash or provisions to the cultivating labourers until the reaping of a crop, and the cultivator is precluded under an agreement from selling his share to any other than the landlord, the price paid for being 1*s.* to 1*s.* 6*d.* per dozen according to the date of production. 18 months to 2 years must elapse between the planting and the reaping of the first crop, each plant producing one fruit. Sometimes a plant bears in 12 to 15 months. When ripe, the pineapples are cut and carried on the heads of men and women to the beach nearest the plantation whence they are shipped in large American vessels. The London Market is principally supplied by the Azores and Canary Islands. But the best pineapples are grown in English hot-houses. It is a mistake to suppose that the best fruits grow in shade. Pineapple does grow in shade, but it grows better in the open especially in the lower districts of Bengal where the climate is moist and equable. In districts where the soil is dry, or rocky and harsh, it grows better in shade. The Mauritius variety which we have in the Sibpur Farm is a superior variety. The Sylhet and Assam pineapples generally, are also famous.

490. *Manure.*—Cotton seed meal and tobacco dust at planting have been found to be the best preparatory manures for pineapples. A month before fruiting bone-dust gives the best result.

491. Pineapple fibre sells at 150 dollars per ton in London and New York. Ten leaves weigh about a pound and 22,000 leaves a ton. A ton of leaves yields 50 to 60 lbs. of clean fibre obtained by scraping and beating, steeping, washing and finally exposing the fibre to the sun. The steeping, washing and exposing to the sun are repeated until the fibre is white,

492. If the fruits can be preserved or even the juice of the fruit, by our cultivators, pineapple-growing would prove highly remunerative. The following recipe is recommended for preserving the juice of all soft fruits: Press out the juice of the fresh fruit, separating it completely from seeds and skin. Then submit the juice to heat of 180° F. (never higher than 190° F. nor lower than 175° F.) for half an hour. Next filter it through a conical flannel bag, to extract the coagulated albumen and other flocculent matter. Then put in bottles. Place these in a trough of water up to their necks and bring the water to a temperature of 200° F. (keeping it always below the boiling temperature *i.e.* 212° F.) The bottles are to be kept at this temperature only for a quarter of an hour, and then corked and sealed at once before cooling. The corks used should remain in the hot water in which the bottles are placed.

493. The fresh juice of the ripe pineapple fruit in teaspoonful doses, has been found a remedy for diphtheria and bronchitis.

494. A word of caution is necessary to persons desirous of introducing such new fibres as rhea, pineapple and agave. The fibres of these like the fibres of jute are not of uniform fineness. Only 10 or 15% of the pine fibre is of silky and delicate fineness which would fetch £30 or £35 per ton in the London market. It should be also remembered with regard to pineapple fibre, that about 150 years ago it formed an important article of export from Chittagong and the Straits Settlements and it was woven in *dhoties* and sheetings in the Dutch possessions. Cotton has gradually ousted it from the field. With improved machinery capable of spinning even yarns out of short staples, pineapple fibre may become a favourite textile material again but its re-introduction must be looked upon only in the light of a hopeful experiment.

CHAPTER LIV.

PLANTAINS (MUSA PARADISSICA).

BANANA jelly.—Plantains being largely grown in Bengal, a simple method of preserving this fruit successfully carried out at Sibpur, may be described with advantage. Peel the ripe fruits, cut them into slices, add 1 lb. of water to each pound of slices and boil for about one hour, until the mixture is soft enough to be strained through calico. After straining add one pound of sugar and sufficient citric or tartaric acid, or simply lime juice, to give the mixture an agreeable acid taste. If citric or tartaric acid is used it should be dissolved in water before it is added to the fruit pulp. The boiling should then be repeated for at least another hour, and then bottle up the jelly when fairly hot, the bottles used being fumigated inside with a taper of burning sulphur introduced immediately before the warm jelly is put in. A piece of parchment paper is put on the top of jelly before the cork or stopper is put on after the jelly has become quite cool.

496. *Banana-meal.*—The *banana* plantation is looked upon in some parts of Africa as an important source of food-supply. Banana-meal is a highly nutritious and light food, and according to Humboldt is 48 times more nutritious than potatoes, and according to Crighton Campbell of America it is 28 times as nutritious as the best wheaten bread. The Negroes prepare banana-meal in a primitive fashion. They dry the fruits and pound them in a mortar. Placed in jars or sacks, away from damp, it remains good for a long time. But a quick-drying apparatus should be used if the meal industry is to be introduced into a damp country like Bengal. The fruits are stripped of skin and cut in rounds and placed on a perfectly cleaned and heat-disinfected trays in the

dessicator. When perfectly dry the chips are ground and passed through a sieve. The produce of meal is 20 to 25 per cent. of the weight of fruits used. 15 lbs. of fruits will give 3 lbs. of meal. It contains 1.455 of N=9.01 per cent. of albuminoids. For making meal it is preferable to use fruits which are not altogether ripe and which contains more starch than ripe fruits. The fruits on analysis give the following average results :—

	Unripe bananas.	Ripe bananas.
Water	70·92	67·78
Starch	12·06	Trace
Grape-sugar ...	0·08	20·47
Cane-sugar ...	1·34	0·50
Fat	0·21	0·58
Albuminoids ...	3·04	4·72
Crude fibre	0·36	0·17
Tannin ...	6·53	0·34
Ash	1·04	0·95
Other matters ...	4·62	0·79

497. *Varieties.*—The principal varieties that are ordinarily cultivated in Bengal, or have been introduced with success, are,—*Martamán*, *Champá*, *Chini-champak*, *Kánthâli*, *Sabri*, *Anupan*, *Ram-rambhá*, *Kanai-bashi*, *Agnishwar*, *Bombay*, *Singapuri*, and *Penang*. *Kánchkala*, which is ordinarily used as a table-vegetable, is also eaten in the ripe state by the poorer classes. *Martamán* and *Champâ* are the ordinary good varieties.

498. *Soil.*—Clay-loam soil not subject to water-logging and situated close to a tank, ditch, jhil, or canal, should be chosen. The land should be ploughed up and while a crop of *Aus* paddy is growing the suckers should be planted 8 cubits apart in the rainy season. The pit should be made a cubit deep and manured with cowdung. The intervals should be ploughed and crossploughed once a year, and silt from the tank, canal, or jhil, applied in April as manure

round the base of each clump. In one year the tree should be in bearing. When the bunch of fruits has formed properly, the portion of the inflorescence hanging on should be cut away that the nourishment which would have been wasted on it might go to develope the properly formed plantains. The tree should be cut down from the base as soon as a bunch has ripened. No clump should have more than 3 suckers at its base. All extra suckers should be taken out in June or July and planted elsewhere if necessary. The leaves should not be cut away except from trees that are cut down after they have borne fruits. 300 to 600 bunches of plantains yielding about Rs. 150, may be expected per acre per annum from a plantation of bananas. The coarser kinds being more prolific than the finer kinds, the variety makes little difference to the outturn under ordinary treatment.

499. The *kánthâli* variety produces the best fibre. The leaf sheathes may be passed through a sugarcane mill with smooth rollers, then combed on both sides with a brass comb which will bring out most of the cellular substance. The blunt edge of a sickle may be afterwards used for getting more of the cellular substance out. The bundles of fibre are then to be washed in water and afterwards boiled with ashes or soft-soap and then rinsed well in plain water, wrung and exposed in *thin layers* to dry *in shade*. The bundles of fibre are to be exposed to dew for three successive nights and in day time the drying should proceed in the shade. Plantain fibre is worth at least twice as much as jute.

500. Manilla hemp is the produce of a plant (Musa textiles) allied to banana. It is very much superior to the fibre obtained from *kánthâli* plantain trees.

CHAPTER LV.

POTATO (SOLANUM TUBEROSUM).

ROTATION:—Potato is usually grown after *Aus* paddy, or jute, or, in tracts of country where the potato is the principal crop, it often forms the only crop of the year. In the district of Baghelkand two crops of potatoes are taken from the same land in one year. It is best to grow a crop of *dhaincha* (Sesbania aculeata) or *sunn*-hemp, between June and August and plough the crop in August. This green manuring adds considerably to the produce of potatoes. Lime and fresh ashes together, say 15 mnds. per acre, should be used if green manuring is done, to hasten the decomposition of the manure and prevent insect-pests.

502. *Soil.*—The soil should be a sandy loam, of a fine texture, but not clay loam. Such soil, if it contains a good deal of humus matter, which makes it retentive of moisture, is best suited for the crop. Shallow, sandy or stony soils and heavy clay soils, are not suitable for potato. Sandy soil improved by the admixture of *jhil* or pond silt answers very well. Stagnant water is very injurious to this crop and if sowing is done early, in September or October, the land chosen must be high and capable of easy draining. The site selected must also be close to water as irrigation is very necessary for this crop in most districts.

503. *Cultivation.*—Deep cultivation and thorough pulverizing of the soil are essential. Two ploughings and two cross-ploughings with the Sibpur plough followed by one grubbing with a five tined grubber and one cross-grubbing should be done as soon as the rainy season is over, the 3 series of operations being conducted at intervals of one week between the operations. Then should follow one or two harrowings

for collecting weeds. It may be necessary to handpick the *Sunn* or *Dhaincha* stalks before commencing ploughing if either of these crops is grown as a preparation for the potato crop. The highest manurial value is attained by these preparatory crops, when they are in flower, and they should be cut then, and if from August to September the stalks do not get sufficiently decomposed by submergence under water, ploughing and liming should be done after handpicking. The cost of picking, however, will be more than realized by the sale of the dry stalks afterwards for fuel or as stakes for the pea or pan crop. The harrowing should be followed by a bakharing or laddering to bring the land to a level seed-bed. The land should then be prepared for irrigation before sowing is done as the making of irrigation channels after sowing uproots a number of seed-tubers. The field is first divided from its head, or main channel for irrigation, to its bottom, into a number of long strips 6 ft. wide separated by water-channels about a foot wide, leading from the main channel at the head of the field to the bottom. The strip of land 6 ft. wide should then be divided into ridges and furrows 18″ from one another. Along these ridges 6 ft. long and 18″ wide potatoes should be planted early, say in September or early in October, 4 inches from one another and 4 inches deep. This is a very costly method of preparing the land for potato cultivation and one which can be practised by cultivators only on a small scale with the object of bringing the crop early to market. Early sowing is however very risky. Heavy rain taking place after sowing may do a great deal of damage by actually rotting the seed or disturbing the irrigation arrangements and washing down the ridges. Early sowing also very often results in insects destroying a portion of the crop. But in localities such as parts of Burdwan, Birbhum and Sonthal Perganahs, where rain-water sinks into the soil or flows on freely, early sowing is advantageous. Pickling of seed in a mixture consisting of sulphate of copper, ashes and castor-cake and the use of lime

or ashes to rot the *dhaincha* or *sunn*, are great preventives against insects.

504. For cultivating potatoes on a large scale, the ridging plough should follow the bakhar or the levelling board, beam, or ladder. The field should be as long as possible and the ridges should be at right angles to the main irrigation channel. The ridges made by the ridging plough will not be absolutely straight, but if trained bullocks are employed they will be sufficiently straight for the purpose of the agriculturist, and they should be about 24″ apart. The sowing in this case should be done after all fear of late rain is over, say about the 20th to the 31st of October or even later. The sowing should be done in this case not along the ridges but along the furrows. A man should make a straight channel 4″ to 5″ deep with a narrow spade or Planet Jr. hoe simply by running the implement along each furrow and between two adjacent ridges. Another man should put in two rows of pickled potatoes 6 inches apart both ways, and cover up the channel as he goes on following the man who is making the channel, while a third man goes on putting manure along the covered channels only. Instead of spreading the manure all over the field this will be found a more economical way of using the manure. Planting deep in between ridges also saves the cost of irrigation. The two earthings are to follow the manuring. The practice of applying the manure in two doses, at the time of the two earthings, does not seem to be justified, unless highly soluble manures, such as saltpetre, are used. Castor-cake, bone-meal and cowdung, which are ordinarily recommended for use, are not so highly soluble and applying them in one dose after planting the seed is advisable. In fact, cowdung should be applied at an early period of preparation of soil and bone-meal or powdered apatite should be first converted into super by the addition of sulphuric acid before applying it to the trenches after planting seed. Bone-meal and apatite being comparatively insoluble manures do not have much effect on a short

lived crop like potato. Potatoes are benefited by high manuring and one of the following manures is recommended for use :—

	maunds per acre	
(1) Bone-super ...	... 6	applied immediately
with castor-cake (powdered)	... 18	after planting.
(2) Rotten cowdung ...	... 400	applied before planting.
with ashes or lime ...	... 15	applied after
and castor-cake ...	... 15	planting.
(3) Rotten cowdung ...	... 600	applied before
with bone-super ...	... 6	planting.
(4) Castor-cake ...	... 30	applied immediately after planting.

(5) Apatite-super 5 maunds and Saltpetre 2½ maunds per acre, both applied immediately after planting.

505. Whether the plants all come out within a fortnight or not, the first watering should take place within ten days to a fortnight after planting, unless a good shower of rain makes this watering superfluous. The tardy sprouts will come up after the watering. If seed-potatoes are kept in-doors under a heap of moist straw for a week or ten days before planting, the sprouting will be quicker and more even after planting. Instead of flooding the field or running the water along the channels in which the seed potatoes are imbedded it is best to distribute the water from the channel by means of an irrigation spoon or *thali*. This prevents caking of the soil. But if the water is run along the channels in which the potatoes are imbedded, hoeing should be done within a week after the irrigation to allow the sprouts to come up without resistance. The first earthing up with *kodalis* should take place when the plants are 6″ to 9″ high. Then should follow two waterings at the interval of a fortnight and then the second earthing. If the soil looks dry, irrigation should take place before and after the two earthings at shorter intervals, say, once in 10 days. 3 to 6 irrigations are necessary, according to the

nature of the locality and of the season. But in some northern and eastern districts of Bengal potatoes can be grown without irrigation which is a great advantage.

506. Potatoes are not ready for lifting until the leaves and haulms have withered completely and the land has become quite dry. Potatoes require about 3 months to mature from the time of sowing and February and March are the ordinary months for harvesting, though by sowing early in September or October lifting can be done in December and January. Lifting is best done with the Hunter hoe unless a potato-digging plough or a potato-digger is used. Perhaps a larger proportion of tubers gets cut when the Hunter hoe is used than when spade is used. 100 maunds to 150 maunds per acre is a fair outturn, though as much as 300 maunds per acre are sometimes obtained.

507. It is difficult to preserve the seed of the superior and large sized hill potatoes in the plains, and one of the chief obstacles to the spread of the cultivation of the Nainital potatoes has been the high price that has to be paid for the imported seed at the time of sowing. If each cultivator could store his own Nainital potato-seed there would be no occasion to grow the inferior *Deshi* varieties. The following plan may be tried. Small thick-skinned tubers are to be selected, spread out in the sun for a day, then strung up with the help of needle and thread previously dipped in a strong solution of sulphate of copper. These strings of seed-potatoes may be kept hung up from the roof secure from rats and ants, in a cool but well ventilated place. Any rotten potatoes noticed on the strings should be at once cut out and destroyed.

508. Steeping of potatoes in a dilute solution of sulphuric acid (2%) for 10 hours and then wiping them dry and storing on sand has been recommended for potatoes meant for food; but this experiment has failed both at Sibpur and at Berhampore, and the method is probably inapplicable for this climate. New and vigorous races of potatoes are established in tem-

perate countries by propagating the plants from seed. Seed-tubers from hill-stations or from a temperate climate give better crops. As it is difficult to preserve the seed of these superior varieties in the plains until next sowing season, and as the exchange of seed with a hill country or a temperate climate has been found beneficial, the attempt to preserve seed may not be attended with good results, *i.e.*, degeneration is likely to follow. The cost of seed is the great obstacle to extensive cultivation of high-class potatoes. In October, when sowing is done in Lower Bengal, seed costs Rs. 5 or Rs. 6 a maund, and an acre of potatoes costs about Rs. 75 in seed alone. As very small sized potatoes do not give good result, a large weight of seed is required. So far all attempts to preserve seed potatoes (except of the poor country varieties) has only partially succeeded in Lower Bengal. An interesting experiment has been instituted at the Sibpur Farm with a view to do away with this difficulty in connection with the high price of seed, but as it will take another season to complete this experiment, we can speak of it only with reserve. It has been observed that in May or June, *i.e.* after the first showers of rain after the potato-harvest, stray potatoes left in the field germinate and if these are planted on a high bed, they continue growing through the rainy season, but produce no tubers. It has been further observed that in February and March when potatoes are lifted, some of the tardy plants are still green, and that when these green stems are planted in well-manured and properly prepared soil, they send out fresh shoots. The question that remains to be solved next season is, whether the plants from stems or tubers (which are only thickenings of the stems) grown in summer and in the rainy season, will yield a crop of cuttings in September, which can be used for seed instead of tubers. If the experiment gives a positive result, and if next year's plants grown from cuttings instead of tubers, yield a good crop of tubers, the difficulty in connection with the cost of seed

will have been solved. All that a cultivator will then need to do is to make use of the stray plants that appear in his potato fields in June or July, and all the stems which are still green but mature, at the time of the potato harvest (which at this stage are rich in the reserve of food material) and to grow a crop of stems only on high beds during the rainy season which may be utilized in September or October as cuttings or seed, thus doing away with the necessity of buying seed potatoes altogether. The potato plants grown in the rainy season will be found particularly subject to the attack of insect pests, but these can be successfully fought against by the application of insecticidal dusts with the help of a pair of bellows employed for this purpose. As the Sibpore experiment has not been completed yet we can only speak with some amount of reserve on the success of the experiment here described and the probabilities are we will not be able to stem the tide of degeneracy even if the stems used as cuttings in September or October produce a crop of tubers of some sort.

509. The expense per acre may be calculated thus :—

	Rs.	A.	P.
Two ploughings and 2 cross-ploughings with Sibpur plough	3	0	0
Two grubbings	1	8	0
Picking *Dhaincha* stalks or 2 harrowings ...	1	8	0
Fifteen maunds of lime	12	0	0
Spreading Do	1	8	0
Laddering or Bakharing	0	12	0
Ridging with double-mould-board plough ...	0	12	0
Seed 10 maunds	50	0	0
Pickling seed	3	8	0
Planting „	6	0	0
Castor-cake (30 maunds)	60	0	0
Spreading „	2	8	0
Two earthings „	6	0	0

	Rs.	A.	P.
Four irrigations	12	0	0
Harvesting	6	0	0
Rent	3	0	0
Total Rs. ...	170	0	0
Outturn 150 maunds at 1-8 ...	225	0	0

Net profit about Rs. 50.

CHAPTER LVI.

BRINJAL (SOLANUM MELONGENA).

NEXT to potatoes *beguns* or brinjals (called also egg-fruits and aubergines) are the most highly prized vegetable of Bengal.

511. *Soil.*—High well drained sandy loam or garden soil not too rich in organic matter, suits this crop best. In clay soil the fruits of *begun* and *patal* become small though sweeter. An excess of organic or nitrogenous manure or organic matter present in the soil, gives rise to the development of leaves at the expense of flower. At the Sibpur farm it has been noticed that unmanured plots give better result than plots manured with saltpetre and cowdung. Being very subject to diseases and attack of insects, it should not be grown in the same locality oftener than once in 5 or 6 years, and the land should be kept well drained, as stagnant water gives rise to fungoid diseases. The free use of lime and ashes at the time of sowing and transplanting is also recommended.

512. There are two distinct varieties of brinjals. Muktakeshi, Makra, Chhatare and Elokeshi belong to the ordinary class, but *kuli begun* growing in bunches and bearing fruits

for a much longer period is botanically a different variety and is sometimes designated S. longum.

513. *Seed.*—When the biggest first fruits are ripe and golden yellow in colour they are removed from the plants and cut right through the middle. In this state they are kept in a heap for 2 days. The seeds are then easily detached, washed clean in water and dried in the sun. The sowing is done in a seed-bed for which a cool and shady place should be chosen. The soil is well pulverised with *kodali* and hand, and well rotted manure mixed with lime and ashes applied. This should be done in January or February while the sowing should be deferred till the end of March or still later, the usual time of sowing the seed in Lower Bengal being early in May. Thorough weathering of the soil should take place and exposure of the seed-bed to the attack of birds before sowing is done. After a shower of rain or watering of the bed by sprinkling, seed is sown evenly but pretty thick and the hand is lightly rubbed over the bed to give the seed a covering. Every evening except when there is rain the seed-bed should have a light sprinkling of water (say with a water-can furnished with a rose). If the seed-bed is in shade well protected from the sun no other protection will be required, otherwise the bed should be covered with palm or plantain leaves until the germination takes place in 3 or 4 days. Light watering should be continued every evening, after germination also. If a heavy shower of rain takes place the seed-bed should be carefully drained of standing water. If insect pests appear, ashes and lime should be dusted on the plants.

514. *Transplanting.*—The field where the seedlings are transplanted should be also prepared very early in the season, *i.e.* in December or January. This should be done with *kodáli* or with Sibpur plough and grubber. The grubber should be passed afterwards onec a month until planting. By the middle of May the land should be levelled and got ready for planting. Drains are made all round the field and a few water channels

running through the field, as in the garden cultivation of potatoes. Then *julis* or furrows are made 36″ apart and the *begun* seedlings planted along the middle of the *julis* after a heavy shower of rain. If planting is done early in the season *i. e.* in April or May, transplanting the seedlings may be done on the level plot 36″ apart instead of in furrows and the water channels are made afterwards. Mustard-cake and ashes and lime should be applied finely powdered under each plant at the time of transplanting. Cowdung and castor-cake encourage the growth of vegetation at the expense of flowering and fruiting. 6 maunds of mustard-cake and 3 maunds of ashes and 1 maund of lime are a sufficient application for one acre. In a fortnight or 10 days the *kodali* should be passed between the rows of plants, thus levelling the field. Blanks noticed should be filled up at this time. After another fortnight the *kodali* should be passed once more between the rows of plants converting the furrows into ridges. Irrigation may or may not be necessary according to the character of the season and the time of planting. If planting is done after a heavy shower of rain, in June, irrigation will not be generally necessary till November ; but if it is done in April or May, irrigation will be necessary at least once to save the crop from drought. From November to March irrigate once a month. By April the crop will be done. The fruits will begin to bear in August. From August to October one more earthing is required when the land is somewhat dry.

515. *Kuli begun* seed is sown in September and October ; the seedlings are transplanted in October and November, and they bear from February to June. From May to August the ordinary brinjal plants may be made to bear fruits if trees that show signs of decay by February or March are pruned, dug up, manured with mustard-cake and ashes, and watered. Fresh shoots will be thrown out and fruits of a somewhat inferior quality will be borne.

516. *Dhashalaga* and *Tulshimara* are the commonest fungoid diseases of brinjal which the cultivators attribute to not cutting the tap-root at the time of transplanting and also to the roots getting cut at the time of earthing. These are fictitious causes. Root-cutting has something to do, no doubt, with the vigour of plants, and cutting of roots when there is water-logging may indirectly cause spores of fungi to settle in the tissues of the plants, but the exciting cause of the diseases is the presence of the spores in the seed, of a bacillus (Bacillus Solanacearum). Water-logging helps the spread of the bacillus. Every plan taffected with a fungoid disease must be uprooted and burnt. The seed used should be pickled and the same locality always avoided for growing this crop from year to year.

517. *The cost* per acre might be estimated as below :—

	Rs.	A.	P.
Ploughing &c.	18	0	0
Manuring	16	0	0
Planting	1	8	0
Watering	10	0	0
Hoeing	12	0	0
Rent	3	0	0
	60	8	0

The outturn of 150 maunds of brinjals at a pice a seer comes to about Rs. 90, and the net profit to about 30 per acre.

CHAPTER LVII.

PATAL (TRICHOSANTHES DIOICA)

NEXT to potatoes and brinjals, this is the most favourite table-vegetable in use in Bengal. The leaves and tender shoots of the creeper (called *Palta*) are eaten cooked, specially by convalescents. *Sandy loam* is best suited for this crop as for most cucurbitaceous vegetables. It grows well on river sides, even on the sides of rivers containing an excess of common salt provided the soil is not heavy.

519. Four or five ploughings and harrowings at the end of the rainy season, followed by making of holes in parallel lines 6 ft. apart, and planting of adventitious roots and joints cut up into lengths of about 3″ each, two in each hole, are the first operations required. The holes are covered with straw and watered every other day to hasten sprouting, except when there are seasonable showers. When the plants have all come up, *i. e.* about November, one hoeing is given and then raised beds are made, as water-logging is highly injurious to the creepers. Each bed should have one row of plants and the bed is made sloping towards the channels. The earth dug up in making the channels is utilised in raising the beds. If the field is very long one or two water channels are made across the field also intersecting the other channels at right angles. One irrigation done in February hastens the fruiting in March. Fruiting goes on from March to September, after which a light ploughing followed by weeding in October and one or two irrigations in February and March will keep the crop for a second year. Usually no manuring is done for *patal*, silt being depended upon. Ashes and lime or bonedust would be of benefit if the crop is kept on a second year on high land.

520. *Cost.*—

	Rs.	A.	P.
4 ploughings	3	0	0
Planting	6	0	0
Spading or earthing (15 men) ...	3	0	0
Watering	4	8	0
2 weedings (12 men each time) ...	3	0	0
Cost of cuttings or roots ...	4	0	0
Rent ...	3	0	0
Total Rs. ...	26	0	0

Outturn, 100 maunds at 1 pice a seer about comes to Rs. 60.

CHAPTER LVIII.

CHILLIES (CAPSICUM FRUTESCENS).

LIKE brinjals, chillies are very much subject to fungoid diseases but they are not so subject to the attack of insects. *Dalbhanga rog* and *Kutelaga* are the commonest fungoid diseases. When these overtake a crop it is not feasible to stop them. In fact chillie cultivation has to be given up for 2 years successively in a locality affected with either of these diseases before it can be taken up again. The Bordeaux mixture and invigorating manures have been used in vain. Besides the ordinary Capsicum frutescens of Bengal may be mentioned the C. annuum or Nepaul chillies and the C. minimum or *Dhani lanka* which are varieties more highly prized for their greater pungency. Cayenne pepper is made out of C. annuum. Some bright coloured varieties of C. annuum have however no pungency at all and these are preferred for the feeding of birds as they are supposed to heighten the colour of their feathers.

522. *Soil.*—Sandy loam and newly formed alluvium on the banks of rivers do well for this crop, but dry rocky soils containing plenty of lime produce the best crops, if they are sufficiently loamy.

523. *Rotation.*—It generally follows one of the pulses or oil-seed crops, and it is sometimes grown after potatoes. It is followed by *Aus* paddy.

524. *Cultivation.*—The land is to be prepared exactly as in case of brinjals. The seed is sown in May in a nursery situated in shade as in the case of brinjals. When 6 or 7 inches high in the seed-bed, the seedlings are transplanted after a good shower of rain 27 × 18 inches apart. The time of transplanting is July and August. When the plants have established themselves in raised beds well protected from stagnant water, their roots should be partially exposed to light and air by removing the earth from their bottom. A month after this, mustard-cake at the rate of 6 mnds. per acre is put at the bottom of each plant and the plant earthed up at the same time. The field should be kept clean of weeds, two hand-weedings and two wheel-hoeings being recommended. 1 or 2 irrigations may be required after November, and a hoeing after each irrigation.

525. December to February is the proper harvest season for ripe chillies, though chillies are also plucked green in October and November and sent fresh to market. Plucking should be done about 4 times, 5 men being required per acre each time. The ripe chillies are spread out in the sun for about a fortnight. Night dew does them no harm and they may be left out day and night for a fortnight, but if rain is feared they must be brought in doors.

526. The yield per acre is 6 to 15 mnds., each maund selling from Rs. 4 to Rs. 7. Unless a tract is known to be particularly adapted for chillies, it is risky growing this crop for profit. The cost per acre comes uniformly to about Rs. 50, while the outturn may vary from Rs. 25 to Rs. 100.

The cost may be estimated as below :—	Rs.	A.	P.
Ploughing and making of beds ...	12	0	0
Transplanting	2	8	0
2 Earthings	6	0	0
2 Hand-hoeings	6	0	0
2 Wheel-hoeings	1	8	0
1 Irrigation	2	8	0
1 Hoeing with spades after irrigation ...	3	8	0
Plucking and drying	5	0	0
Rent	3	0	0
Total Rs. ...	42	0	0

CHAPTER LIX.

ENGLISH VEGETABLES.

NEXT to potatoes, palvals, and brinjals, the English vegetables, viz. cabbages, cauliflowers, tomatoes, knol-kohl, turnips and beet, have come to be regarded as the important table-vegetables, specially in Bengal towns.

528. What are known in India as English vegetables did not all originally come from England. The original home of cabbage, carrot, celery, parsnip, salsify, sea-kale and turnip, is believed to be England. But beans came originally from Persia and India; beet, broccoli, cauliflower, lettuce, parsley, and peas came originally from Southern Europe or Asia; Brussels sprout as its name implies originally came from Belgium; kohl rabi from Germany; leek from Switzerland; endive from East Indian Islands, Jerusalem artichoke from Brazil; potatoes from Peru; tomatoes from South America onion from Africa; radish and rhubarb from China and spinach from Northern Asia.

529. Taking into consideration the land of their origin

we should infer that for this climate cabbage, carrot, celery, parsnip, salsify, sea kale, turnip, Brussels sprout, kohl rabi, leek, and spinach are not suitable. But experience shows that nearly all the vegetables mentioned above can be successfully grown even in the climate of Lower Bengal specially in the cold weather, though it is necessary to import the seeds of those varieties which are natives of the temperate climate, from such climate. Cabbage and cauliflower seeds from Patna, and onion seed from Poona, and country carrot seed from any part of Bihar, give good result.

530. The following points may be particularly noted in connection with the growing of English vegetables :—

(1) Any seed with a tough coat should be soaked in water at a temperature of about 60° F before sowing. The seed should be sown when still damp and it should be covered with fine leaf mould 1″ to 3″ deep according to the size and strength of the seed. Pea and bean seeds, for instance, should be sown 3″ deep, while only a very light covering of less than $\frac{1}{4}$″ of loam or mould should be put on celery or lettuce or cabbage seed.

(2) The seed is to be sown in a raised and well pulverised seed-bed manured with well-rotted manure and leaf mould, the soil consisting of friable sandy loam, clean and without grit or stones. There should be a cover of mats on the seed-bed, or sowing should be done in boxes in a verandah. Seed should be sown at the close of the rainy season. After scattering the seed on the seed-bed a light cover of leaf moulds should be put on it and on that, ashes are to be sprinkled. Ashes should be sprinkled on the seedlings also, as soon they appear.

(3) After germination, the covering mats are to be taken off every evening if no rainfall is apprehended at night, and the cover put on again at 8 or 9 A.M. Some sunlight is needed for seedlings or else they grow up into sickly plants.

(4) Water is to be gently sprinkled on the seedlings as

occasion requires, —say, once in 2 or 3 days, if the soil looks dry.

(5) When there are 4 to 6 leaves on the seedlings they are ready for transplanting.

(6) Carrots, turnips, beet, mangold, tomatoes, salsify, spinach, onions, peas and beans, are not transplanted from seed-beds, but sown where they are meant to grow. Where plants grow too thick they are thinned out. Beet, and tomatoes may be sown in seed-beds and afterwards transplanted. Onion and celery also do whether the seedlings are transplanted or not.

(7). Before transplanting the seed-bed is to be well soaked with water.

(8). Transplanting should take place in straight lines and at such distances apart that water channels may be made easily.

(9). Dwarf beans both broad and kidney should be sown 2 feet apart and 5 inches in the lines from plant to plant. Tall beans should be sown 3 ft. × 5″ apart; peas 4 ft. × 2 inches; and beet 18″ × 9″ apart. Broccoli and cabbages should be planted 2ft. × 2½ft. apart; Brussel sprouts (which are suited to poor soils and do well even without manuring) 2 feet. × 1½ feet apart; carrots 10 inches × 6 inches apart; celery and leek 6 inches apart in nursery-beds before they are transplanted for the second time into trenches which should be 1 foot deep and 1¼ ft. wide, the trenches being 4 ft. apart. Endive salad should be planted 1 ft. × 1½ feet apart; onion 15 inches × 9 inches apart; garlic 1 foot × 6 inches apart; parsley 1 foot × 1 foot apart; kohl-rabi 18 inches × 15 inches apart; parsnips 15 inches × 12 inches apart; and turnips 1 foot × 6 inches apart.

(10). Quantity of seed required per acre.—

Brussels sprouts, Broccoli, and Parsley ...	2 ounces.
Cabbages	4 ounces.
Onion (setts)	10 seers.

Onions and Carrots (seed)	...	...	8 ounces.
Leek and Celery ...	...	...	1 ounce.
Radish nnd Endive ...	...	...	1½ ounces.
Lettuce	...	...	3 ounces.
Turnips and Parsnip ...	...	...	6 ounces.
Beet	...	...	2½ seers.
Peas and Beans ...	...	...	1 maund.
Jerusalem Artichoke (bulbs)	...	...	5 maunds.

(11). Castor leaf, arum leaf, *bur* leaf, plantain leaf or leaf-sheath, or some such article must be used in day time, for protecting the seedlings against the sun, for a week after transplanting.

(12). Thorough previous preparation of land where the seedlings are transplanted is necessary to avoid insect pests, also use of mustard cake, ashes, lime, salt, white arsenic, asafœtida and aloes as an insecticidal mixture at the time of transplanting. A handful of the mixture can be mixed up with the soil where each seedling is planted.

(13). Cabbages, knol-kohl, broad beans and tomatoes do well on the heavier classes of loam and broccoli, cauliflower, kidney beans, turnips, onion, garlic, beet, radishes and carrots, on the lighter classes.

(14). Cabbages are specially benefited by saltpetre at 10 maunds per acre, cauliflower by mustard cake and lime or ashes at 10 mds. and 5 mds. respectively per acre; but turnips and knol-kohl are especially benefited by bone-super at 6 mds. per acre accompanied by heavy manuring with farmyard manure. Carrots and radishes prefer cowdung at 200 mnds. per acre, and tomatoes are specially benefited by cowdung ashes.

(15). The following mixture has been found particularly good for growing English vegetables: Fowl manure, two baskets + powdered cowdung cake, three baskets + ashes, one basket + gypsum, one basket. Moisten the whole with fresh urine at the time of application of the mixture, and apply

one handful at the bottom of each plant, after it is fairly well established in the field. Vegetable marrows, beans, maize and potatoes also are specially benefited by this manure.

(16). Irrigation is most essential and whenever the land looks dry irrigation must be resorted to followed each time by one wheel-hoeing. 4 to 8 irrigations are needed according to the climate and the character of the soil. The land should be divided into ridges in making the irrigation channels which will involve loosening of the bases of the plants and earthing them up.

(17). It is best to buy reliable English seeds or seeds from Mussoorie or some other hill station grown by a well-established and reliable firm, instead of depending on plain seeds though they may be had cheaper. Patna cabbage and cauliflower seeds and Poona onion seeds, however, give very good result.

(18). Cabbage and turnip seeds like cucumber and melon seeds retain their germinating power for several years, kept protected from insects in a dark receptacle; while seeds of peas, beans, carrots, parsnips and onions are of no use after a year. The germinating power of seeds may be tested by placing them between two pieces of damp flannel kept continuously moist for a weak.

(19). It is better to sow the seeds of all crops (not merely English vegetables) the seedlings of which are raised in seed-beds *i.e.* cotton, tobacco, cabbages, lettuce, tomatoes, &c., in narrow shallow drills in the bed, than to sow them broadcast. Young plants grown in drills are much easier to lift and transplant and to keep clean from weeds, and, as a rule, they are hardier. In sowing small sized seeds in seed-beds one quarter to half an inch of soil above the seed is enough. If the drills are covered in with a little very fine and thoroughly rotten manure, germination takes place quickly and in transplanting some of the manure will be

mixed up with the ball of earth surrounding the roots. In sowing seeds of onion, carrots, radishes and turnips in open ground, have the soil thoroughly tilled, pulverised, cleaned from weeds and levelled previous to sowing. These seeds should be sown in drills 2 feet apart, so that a bullock-hoe may be used between the drills.

(20). In transplanting a dull or showery day should be chosen, if possible, or else the plants thoroughly watered or transplanting done after a heavy shower of rain and the soil round them mulched if mulching materials are available. The plants are to be set a little deeper in the soil than they were in the seed-bed and the soil round the roots should be made firm with the hand without however bruising the necks of the plants. The plants should never be pulled up from the seed-beds but always lifted up, with a little soil adhering to the rootlets. Watering the seed-bed before lifting, helps this. Watering the transplanted seedlings should be done 2 or 3 times a week early in the morning or late in the afternoon, until they are well established. If mulching is done, saving in watering and hoeing will be effected.

(21). In transplanting, the spacing should be regulated by two considerations—1st, that two adjacent plants when fully grown up may not touch each other, and 2ndly, that there may be sufficient space for water channels between two rows of plants. The plants may be thus set closer in lines than in rows. When sowing is done in the open, as in the case of radish, turnips, carrots, onions, &c., the plants should be thinned out, the strongest plants being left, wherever possible, proper regard being had to regularity of the lines and the evenness of distance among the plants.

(22). Transplanted into deep and wide trenches, English vegetables can be grown in the plains, up to June. The irrigation should be done in the trenches, the plants being set on two ridges at the bottom of the trench. The trenches should be made 2 or 2½ feet deep and about the same in

width at the bottom, where two rows of plants should be planted with a water channel in the middle.

(23) Near large towns vegetable-gardening, (called also market-gardening) *i. e.*, growing of potatoes, brinjals, palval, cabbages, cauliflower, turnips, beet, knol-kohl, carrots, asparagus, artichoke, Jerusalem artichoke, *palam sâg*, *dengo sâg* (in the rainy season), chewing sugarcane and English peas and beans, pays well. Ample provision for manuring and irrigation is necessary. Dairying and goat-farming ought also to prove highly remunerative if carried on within a short distance from towns. Vegetable-gardening and dairying may well be combined, as any vegetables that are not readily sold can be given to cattle. Goat-farming may also go well with vegetable farming if proper arrangements for hurdling the goats in can be made.

CHAPTER LX.

CARROT (DAUCUS CAROTA) AND RADISH (RAPHANUS SATIVUS).

CARROT.—The English root-crop which has a special value as a nourishing famine-food and fodder is the carrot. Up-country carrot or *gâjrâ* is not such a nourishing and palatable food as European carrot, and of all the carrots experimented with in this country, the Red Mediterranian variety grown at the Cawnpore Experimental Farm seems to be the best. The Yellow Mediterranian carrot is a heavier yielder but it is more suited as a cattle food. The yield of the White Mediterranian carrot is almost equal to or even higher than that of country carrot, but the roots are hard, coarse and insipid. Without manure the country variety gives a much larger yield than any of the European varieties. Carrots

should not be directly manured. The previous crop should be highly manured but the carrot itself grown without manure. There should be plenty of lime in the soil where carrot is grown.

532. The proper time for sowing carrot seed in the plains is between the 15th September to 15th October, and if famine or scarcity is feared, sowing is done still earlier in the N.-W. Provinces. It is best to sow in drills and ridge the drills after the plants have appeared and then to thin out the plants. 200 mnds. of well rotten dung should be used before sowing, or better still before sowing the previous *Aus* paddy crop. 8 to 12 ounces per acre is the quantity of seed which should be used. The yield comes to 200 to 500 mnds. per acre, if good loose soil near village site is chosen and if the soil is deeply cultivated, well pulverised, weeded 2 or 3 times and irrigated 5 or 6 times. The seed should be mixed up with wood-ashes at the time of sowing, and, unless the soil is quite moist at the time, water should be poured in the drills immediately after sowing.

533. The following analysis of carrots give an idea of the high feeding value of this vegetable : –

	White Medtn. carrots.	Red Medtn. carrots.	English carrots.
Water ...	84·57	84·43	87·30
Soluble albuminoids.	·35	·48	·66
Insoluble ...	·17	·30	
Sugar and starch ...	8·98	7·98	8·10
Crude fibre ...	2·37	3·70	3·20
Woody fibre ...	2·19	1·80	
Soluble mineral matters.	1·09	·99	·74
Insoluble mineral matters.	·28	·32	
	100	100	100
TOTAL N. ...	·175	·230	·200

534. So important is the carrot regarded in the N.-W. Provinces as a stay during famine, that numerous applications were received by District Collectors during the famine of 1896-97 for carrot seed, when the local supply was exhausted. Telegraphic order was sent off at once to Messrs. Carter and Co. for seed and they sent out over 100 tons of seed. It was not before December and January, however, that the seed was in the hands of cultivators, and the imported carrot either failed to germinate or produced only very meagre crops.

535. *Radish.*—This also belongs to the cabbage family and although it is a cold weather crop, the *ság* can be grown nearly all the year round. It and the China cabbage are therefore grown in the Bengal Jails as vegetables for prisoners. In the hills the radish can be grown all the year round. The large and small pale pink radish is liked by Indians, while the small red and round radish is grown to a small extent for European consumers. There are special localities in Midnapur, Birbhum &c., where very huge radishes are grown, but the seeds of these tried in the Sibpur Farm gave the ordinary small sized radishes that we see sold in the Calcutta Bazar. There are certain light soils rich in mineral matters that are therefore specially suitable for the crop. The sowing time is June to December, though the best time is September, and the crop takes only 2 months maturing, which is a great advantage. The seed should be sown in lines 9″ apart and seedlings should be thinned out so as to have them 3″ apart in the lines. Thorough and deep cultivation and watering once in 10 or 12 days, are essential. As there is no very great demand for this crop, except in large towns, and as it is not such a nourishing crop as the carrot, any extension in the cultivation of this crop cannot be recommended, but as a fast growing vegetable, it can be grown by cultivators for domestic use on homestead lands.

CHAPTER LXI.

TURMERIC AND GINGER.

AS these crops can be grown under the shade of trees, and as it is desirable to have trees at the outskirts of a farm, land, which would otherwise remain uncultivated and harbour insect-pests, could be utilized with great advantage by growing turmeric and ginger. Trees (such as mangoes, jack, lichies &c.) are themselves benefited, if the land underneath is kept cultivated. This is one of the principal preventive methods that should be employed in combating orchard-pests. Stiff clay soils are not suitable for any root-crops; but as the soil under trees is never too heavy or too light, any soil which is not too stony, gritty or gravelly will do for growing these crops. The cultivation for both the crops is similar. In putting down virgin soil under trees for the first time under turmeric or ginger, it is desirable to plough up the land in October or November *i. e.* after the rainy season is over and when the land is still in a fit state for ploughing. One ploughing and cross-ploughing with the Sibpur plough followed by laddering should be a sufficient cold-weather preparation for these crops. In April, *i. e.*, after the first shower of rain in the hot weather, another ploughing followed by cross-ploughing and laddering, will render the land fit for planting the bulbs of ginger or turmeric. These should be planted 9 inches apart in the lime, and the lines should be 25 or 30 inches apart. About two maunds of turmeric or ginger seed are required for planting an acre. When the plants have come up and before the approach of the regular rainy season, ridging or earthing should be done for excluding water from the immediate surroundings of the plants. Water should be let out from the field whenever there is any accumulation, or

such land should be chosen, whence water flows out naturally and readily. Manuring is scarcely ever done for ginger or turmeric, but a maund of ashes and 3 maunds of oil-cake per acre would benefit both these and the trees under which they are grown. The manuring should be done soon after planting and before earthing. Two hand-weedings or hoeings are necessary, one in July and the other in September. The root should be lifted up after the leaves have completely withered *i. e.* in December and January. Some small sections of the roots should be set apart for seed. These before being planted in April or May should be kept under a heap of damp straw to hasten sprouting. The rest of the turmeric roots should be cut into two if too fat, dried and then boiled in water mixed up with cow-dung. As soon as the water begins to boil the boiler is to be taken down from the oven, and the turmeric taken out afterwards and spread out in the sun. The heap should be stirred and turned two or three times a day, and when the smaller sections have become quite dry they should be separated out leaving the fatter sections to dry for another day or two. Daily in the evening the turmeric exposed to the sun should be rubbed, the rubbing making the roots clean and smooth.

537. The outturn of turmeric (boiled and dried) comes to about 16 maunds per acre, and of fresh ginger about 50 maunds, but as much as 50 and 150 maunds per acre respectively have been sometimes obtained. The ginger can be sold off in the undried state at about Rs. 4 per maund, while dry turmeric may fetch as much as Rs. 5 per maund. The cost of cultivation comes to about Rs. 50 per acre, in either case.

Other crops that grow well in shade are piper longum (pipul), arrowroot, ground-nut, and rhea.

CHAPTER LXII.

SYSTEMS OF FARMING.

WE have described most of the ordinary agricultural crops. Such crops as *Amarantus Anardana* (a cereal eaten on fast days by up-country people), *Ságs*, garden-herbs or spices, which are grown in very small patches, are not dealt with, as it is not known, if their cultivation will pay if they are grown as regular crops. Such crops as tea, opium, coffee, indigo, round-pepper, sugarcane, tobacco &c., which are of exceptional value and which respond specially to a large outlay of capital, are best suited for the planting enterprise, but they should be dealt with in a hand-book like this. *Planting* differs from *farming* proper, in as much as it is concerned with the growing of one valuable crop only. *Gardening*, on the other hand, differs from both, in as much as the methods, the tools, the manures, used in gardening, are different from those used in farming or planting. A planter is a one crop farmer. A gardener usually grows a great many crops and flowers. But his aim is not to get the maximum amount of nourishing food at the smallest expenditure of capital, but rather to produce the best size, shape, flavour, in fruits, flowers and vegetables, by expensive and highly careful methods of work. The farmer aims at doing without manures, as much as possible, at keeping up the fertility of his land simply by feeding his cattle with nourishing oil-cakes and utilising all the cattle-dung, urine and litter in manuring his fields. By growing leguminous crops and by adopting a judicious system of rotation, he also tries to avoid the purchase of manures. The farmer's methods of cultivation are also of a wholesale character. He does not aim at straight lines and neat curves, at absolute freedom

from weeds, all of which are attainable by the use of hand-tools and at a great cost. By judicious crossing and hybridizing, by the use of Ichthimic guano and Jadoo-fibre, by budding and grafting, the gardener attains exceptional results at a great cost; and yet gardening pays, near large and rich towns, where there are always people who are ready to pay a guinea for a hot-house fine pineapple, where farm-grown pineapples sell at a shilling a piece, where the value of articles is not judged from quantity and intrinsic merit in the shape of nourishment, but from bloom, flavour, look and size. The gardener does not, as a rule, trouble himself with rotation nor does the planter, but the latter growing only one crop has no choice in the matter, while the former usually grows for too many things in small patches on land for which he pays a very high rent, to be able to choose a definite course of rotation, or to adopt the methods in general use in farms. Then there are various kinds of gardens. In tea-gardens, though garden-tools (spades, rakes, forks &c.,) are in use, the one-crop system makes them partake of the nature of plantations. Then there are gardens which are laid out once for all, such as flower-gardens and orchards, and also tea gardens; while market-gardens have to be laid out at least twice a year. A garden, which contains mainly perennial plants, and which is once laid out at a great initial cost, does not cost any more keeping up than a farm. One labourer can look after 2 to 3 acres of garden land as of farm land. But market-gardening costs a great deal more in labour. Even one labourer per acre is not sufficient for every kind of market-gardening, though a mixed garden, where English vegetables, sugarcane, green maize &c., are grown, can be worked with one labourer per acre, if some farm appliances and bullocks are kept. In planting and farming, animal and other powers are utilised as much as possible, while in gardening hand-power is the main stay.

539. The single-crop system, however remunerative at first, is bound to end in failure sooner or later: – (1) Competition brings down prices, increases wages and diminishes profit. (2) The land gets exhausted for this special crop. (3) Special insect and fungus parasites accumulate. (4) The proprietor or the manager understanding only the handing of this special crop thoroughly, sticks to it to the very last and is unable to take to anything else for want of experience and for fear of losing more, until the crop fails entirely.

540. Middle-class men going in for farming should go in for mixed cropping, which gives rest to land if a judicious system of rotation is adopted. They should not say, "We will go in for dairying, or for tea, or, vanilla, or coffee, or banana, or sugarcane, or rice". They should go in for as many things as have a good local sale. They must proceed tentatively, *i. e.*, at first grow only such things as they can consume at home *i.e.*, what they require for the consumption of the members of their family, for their servants and their farm animals. That is the market ready for them. Then they can extend the cultivation of any thing that they find they can grow particularly well on their land, or which suits their tastes and fancy best. If they come to find, that cows are doing very well under their management, that they understand them, and that they would like to keep more of them, they must give dairying some prominence, and begin selling milk and butter and bullocks and bulls. If they find goat-breeding does well and that they would like keeping more goats, they should extend this branch of their farming, though at first they should keep only just as many goats as they require for supplying meat to their family and perhaps some of their neighbours. In this way they should advance from supplying the needs of their own family, to supplying the needs of their friends and neighbours, and then supplying the general market. It is easier and more lucrative to create a special market for produce which shows any speciality.

541. Bearing the above general principle in mind, one should determine the system of farming he is to follow eventually which must be governed very much by local circumstances.

542. The principal systems of farming may be enumerated as follows :—

(1) *The one-crop system.*—Growing the same crop year after year on the same land without manure is the common system of this country. The Jothro Tull system is only a slight departure from this, the land being cultivated deep and well. Deep cultivation and hoeing are not however in vogue in India. The one-crop system suits only a new tract of country. But sooner or later the land gets exhausted. In settling in the Sunderbans one finds the one-crop system (of growing rice only) pays best. But as time goes on the system will have to be altered.

(2) *Bare-fallowing system.*—According to this system no manure is used, and no crop is grown on a particular field once in 3, 4, 5, or 6 years. The Lois Weedon system is an ingenious variation of the bare-fallow system, according to which 3 rows of wheat are drilled 12″ apart and 3 ft. of space left fallow along side the drilled strip, and this succession of cropped and fallowed strips is repeated. The fallow strips are kept cultivated deep and exposed to the action of air. Keeping land cultivated and exposed without crop should not be done in the rainy season. The Jewish system of giving rest to all land every 7th year, also comes under the bare-fallow system.

(3) *Green-crop-fallowing system.*—This is where a green or root crop is substituted for fallow. The land is well cleaned and thoroughly manured first by direct manuring for the root-crops, and secondly by tethering cattle on the land and giving them oil-cake in addition.

(4) *Prout's Plan.*—All things are grown by artificial manures. No live-stock is kept and all the crops are sold off

as they get ready. This is a wasteful plan, except in certain localities where there is a railway station close by and a ready market. The ploughing &c., is done by hired bullocks, and no crop is used for feeding farm animals, even the straw of cereals being sold off.

(5) *All-stock-and-no-crop* system is the opposite of Prout's Plan. The land is mostly let down in grass. Such foods as cake, beanmeal, chaff &c., are bought. The dung is returned to the meadows and the liquid manure is used for irrigating the meadows. On poor land and on hill sides this system may be followed.

(6) *Irrigation system.*—Water, liquid manure, or town sewage, if available in abundance, this system may be followed. For market gardens, for meadow pastures and for green crops, this system is adapted, but not for growing cereals and pulses. Manures need not be applied where there are special facilities for irrigation, as the water itself contains sufficient plant food.

(7) Mixed arable-and-stock-farming is the safest system for most agricultural lands.

(8) Near large towns market-gardening and dairy farming pay better.

(9) Fruit-farming and jam and jelly-making are best adapted for poor lands away from towns but not far removed from railway station or river &c., leading to a large town.

543. The crops to be grown on any particular soil are to be judged from what are actually grown in the neighbourhood and also from the following general directions:—

(*a*). *Clay soils* are suited for rice, *arahar,* sugarcane, wheat, oats, beans, peas, linseed, jute, cabbages, grasses, fruits and trees generally.

(*b*). *Open and free loams* are specially suited for barley, juar, turnips, and root crops generally, tobacco, maize, tea, earth-nut and most English vegetables.

(*c*). *Sandy soil* suits maize, millet, earth-nut, agaves, mustard, *til* and oil-seeds generally, cinnamon tree, date (sandy but well watered places). Cotton prefers dry and porous uplands, and hot, dry, and somewhat droughty climate.

544. *Rotation.*—In adopting any system of farming one must think of a system of rotation that may be adopted having regard to the main object of the farming. Even when one wishes to grow sugarcane in a large plantation, one must think of a suitable rotation where the other crops are treated as mere accessories. When the jungle is cleared by burning, say from March to May, the land will be ready for ploughing in May after a good shower of rain. Instead of putting in sugarcane at once in May or June, it is best to take a crop of *Aus* paddy which is a cleaning crop, or maize. After removing the *Aus* paddy or maize in September the land may be further pulverised, and brought to a thoroughly, 'kind' state by growing potatoes which do very well on new land. After harvesting the potatoes, sugarcane may be planted in February. After the sugarcane has been harvested next February the land may be ploughed up (unless the variety of sugarcane chosen can be ratooned) and a crop of *Dhaincha* (Sesbania aculeata), or Cow-pea (Vigna catiang), or Sunn hemp (Crotolaria juncea), or indigo, taken; then another crop of potatoes, gram or pulse of some kind (*kurthi* being preferred as a cleaning crop), taken, before the land is used again for growing sugarcane. Sugarcane and indigo also make an excellent rotation. In putting down a plantation of a perennial tree such as mangoes or bananas also, one should after clearing jungle (by burning) take a crop of *Aus* paddy, and while the paddy is growing the shoots of bananas, or grafts or seedlings of mangoes should be planted.

545. In ordinary arable farming, a definite course of rotation should be determined upon. The character of the soil should guide one in the choice of a rotation.

546. For *high and light soils*, the following five-course rotation may be adopted :—

First year.—*Aus* paddy (May to September), followed by a pulse or oil-seed crop, or the two crops mixed together (October to March).

Second year.—Jute (April to September), followed by a pulse or oil-seed, or the two mixed together (October to March).

Third year.—*Aus* paddy (May to September), followed by potatoes (October to February).

Fourth year.—Sugarcane (February to February).

Fifth year.—*Aus* paddy (May to September), followed by a pulse crop (October to March).

The field should be thus annually divided into five sections, each of which should be cropped successively in the manner indicated above.

547. For *high and heavy soil*, the following six-course system may be followed :—

First year.—Sugarcane (January to February).

Second year.—Burhi cotton (if virgin soil, and *Arahar*, if old tilth) (May to March).

Third year.—Jute (April to September), followed by linseed and gram (October to April).

Fourth year.—Maize (April to September), followed by *kalai* or linseed (October to March).

Fifth year.—*Aus* paddy (May to September), followed by Barbati or cow-pea (September to February).

Sixth year.—Fallow.

For heavy soils, fallowing a portion of the field every year is desirable. Here the cattle can be pastured and given rich oil-cakes &c. to eat.

548. For *low and heavy* soils, the following five-course system may be followed :—

First year.—*Aman* paddy (June to December), followed by a Cucurbitaceous catch-crop (January to June).

Second year.—*Aman* paddy (June to December).

Third year.—Jute (March to September), followed by *kalai*, *musuri*, *khesari* and linseed (October to March).

Fourth year.—*Aman* (paddy or a sugarcane that can stand water).

Fifth year.—Fallow.

549. For *low and light soils* the following five-course system may be followed :—

First year.—Maize (April to September), followed by *Til* and Barley (September to February).

Second year.—Sugarcane (February to February).

Third year.—Sunn-hemp and Jute (March to September), followed by mustard and country-peas (October to March).

Fourth year.—*Aman* paddy (June to January).

Fifth year.—Cucurbitaceous catch-crop (January to June), followed by *Aman* paddy (June to December).

CHAPTER LXIII.

PROPAGATION OF TREES.

THE propagation of trees which yield starch, oil, sugar, vegetables and fibres, is of vast importance to a country where failure of ordinary agricultural crops through drought or inundation is of frequent occurrence. Apart from their uses for food, fodder and timber, trees are highly beneficial as break-winds in localities where high winds are an objection. They exercise a beneficial effect on the climate and temperature, when there are not too many of them. A moderate sized tree transpires as much as 40 gallons of water per day, which goes to reduce the temperature of the atmosphere, while radiation is hindered at night by trees. Thus trees exercise the influence of equalising temperature. Trees bringing up food materials from the depth of soils and storing them

in leaves which are afterwards shed, are a most valuable fertilising agency of surface soils. Beneath the shade of trees a rich layer of humus is formed which keeps the roots cool in summer and warm in winter, besides absorbing and retaining a great quantity of water. It is in this way that trees grow luxuriantly even on the poorest soils and change the character of the soil permanently for the better. Trees also have a binding effect on the land which without them would be liable to be washed away or denuded by rain. Trees are also believed to induce a heavier rainfall. In the Delta of the Nile there used to be on the average only 6 rainy days in the year; but since the planting of millions of eucalyptus trees there during the last 40 years, there are now on the average 40 rainy days per annum. In Algiers, Napoleon III. caused millions of trees to be planted, which has doubled the number of rainy days in that country. There is an arid belt running through Australia, Africa &c. but wherever forests cross that belt as in New South Wales and W. Australia there is a heavy rainfall. The Himalayas on one side is almost a desert now, but was once very populous until the forests were destroyed. The other side of the same mountains which is heavily timbered, has a large number of big rivers and it maintains an immense population. The propagation of trees also results in a perennial supply of fuel and fodder of the highest value. Trees also act as a barrier against epidemics and such aromatic trees as the eucalyptus and the conferæ are considered especially valuable for this purpose. The casuarina tree which is a conefer, yielding a good fuel and Inga dulcis, which yields a good fodder, are both very fast growing trees, and their propagation is recommended on poor soils. The propagation of the babul for fodder, and timber required for agricultural purposes, is also highly recommended. Slow-growing but valuable timber-trees, such as, mahogany, tun, sal, teak, sisoo, should not be grown in agricultural tracts but in poor and arid tracts which are considered unsuitable, for ordinary agricultural pursuits,

Trees producing tans and dyes, such as, myrabolan, divi-divi (Cæsalpina coriarea, or better still, C. dignya), asan, arjun, cheli, kamela (Mallotus Philippinerisus), lodh, anatto, and other trees with special economic value, should be grown only in special localities which are also not quite suitable for agricultural purposes, *e. g*, in various parts of the Chhotanagpur Division. For agricultural tracts, the trees that should be grown should yield fodder and food or they should be so fast growing that they may yield fuel in abundance and without much waiting, relieving cattle-dung for manural purposes. Lastly, with regard to trees it should be mentioned that they cost scarcely anything keeping up after they are once grown up, and a plantation of mangoes, cocoanut, guava, limetrees, plantains, bamboos, date, jack, papaya and other fruit trees, though expensive and troublesome to set up, is a most valuable property for a capitalist who can afford to wait for the return. Indeed for a capitalist it is much safer investment taking up poor land for such a plantation than going in for ordinary agricultural pursuits. Each tree can be safely relied upon to yield, on an average, 4 as. per annum, if the plantation is situated anywhere within easy reach of a town. An acre would carry about 100 trees of various kinds. After 6 or 7 years the income per acre will be thus about Rs. 25 per annum without any further outlay, and the trees can be annually leased out to fruit sellers at this rate.

551. The trees which are best to grow are :—(1) Mango. Stonekernels of the mango fruit yield a starch which can be used for bread-making, *i.e.* after the kernels have been pounded and washed with hot water. (2) Jack. (3) Bread-fruit tree. (4) Cashew-nuts. (5) Bael. (6) Babul. (7) Jhand or Shami (Prosopis spisigera) which is a moderate sized, deciduous, thorny tree, found in the arid dry zones of the Punjab, Sind, Rajputna, Gujrat, Bundelkhand and Deccan. This tree is as valuable as carob-beans in time of scarcity. The pods, which ripen before and during the rains, contain a consider-

able quantity of a sweetish farinaceous substance. The pods are eaten green or dry, and raw, by itself, or boiled with salt, onions and ghee, with bread or mixed with *dahi*. The bark ground into flour and made into cakes is also edible. This tree was the means of saving thousands of lives during the Rajputana famine of 1868-69. As a food and fodder-yielding tree, there are not many that can be compared to this one. (8) *Sajna* or *najna* may be also mentioned as a food-yielding tree. (9) The mulberry. (10) Bamboo. (11) The mahua. (12) The palms, toddy palm, areca-nut palm, cocoanut palm and the date palm. Plantains and dates being grown as crops in some parts of Bengal, are separately dealt with.

552. Fruits can be variously utilized if they cannot be sold fresh. The strained juice of mangoes and jack fruits is spread out thin in the sun and preserved in the form of thin cakes. A method of preserving the juice of fresh fruits without converting it into wine, has been described in the chapter on Pineapples. Lime juice may be bottled up fresh with the addition of powdered charcoal for an indefinite period. Rapid dessication of fruits and vegetables by the combined action of heat and bellowing, followed by tinning them in air-tight cans, is now resorted to largely in Australia. The Saharanpur experiments in this direction though not quite successful have opened out an important field of economic research. Fruits are also preserved by converting them into jams and jellies. Jams are made by boiling fresh and whole fruits in syrup. The sugar and water are first boiled into syrup and the fruits put in afterwards and boiled. The preparation of jelly from the pulp or the juice of fruits by the addition of sugar has been described in the chapter on Plantains.

553. Lord Sudeley's fruit plantation in England (in connection with which Beech's Jam Factory is worked), is an example of the success which a capitalist can attain by this semi-agricultural pursuit. No calculation can be given of initial outlay, annual expenditure and outturn which will

apply to fruit trees generally, as some trees such as plantains, palms &c., may be planted 6 or 7 cubits apart, while others such as mangoes or jack should be planted 25 or 30 ft. apart. But the above estimate of income of Rs. 25 per acre from a mixed orchard may be taken as a reasonable approximation. Under exceptionally favourable circumstances, however, a net profit of over Rs. 2,000 per acre may be obtained from suitable fruit trees. There is one mango tree in Maldah, for instance, which is leased out annually for Rs. 30, paid in advance, whatever be the number of fruits finally obtained from this tree. Seventy such trees grown on one acre might give a net income of Rs. 2,000 per annum. But one must not base his calculations on very extraordinary and exceptional circumstances, but on the average experience of the country.

CHAPTER LXIV.

THE DATE-PALM.

THE following account of the date-palm taken from Westland's Report of the Jessore District will give some idea of the great value of this tree.

555. "One of the most important industries in the district of Jessore is the cultivation and manufacture of date-sugar. There are so many people who derive from sugar all that they have above the mere necessaries of life, that it may be considered that the sugar cultivation and trade is the root of all their prosperity. In a statistical table prepared in 1791 we

find it recorded that 20,000 mnds. was the annual produce of the sugar cultivation, and that of this about half was exported to Calcutta. In these later years the date-sugar has almost entirely driven away the cane-sugar from the fields as well as from the market. European factories began to be set up in the district, and it was these factories that gave such impulse to the trade. The first sugar-factory in the country was at Dhoba, in Burdwan, a little below Nuddea, and it was erected by a Mr. Blake. When his success began to diminish, he changed the business into that of a company, from which he gradually withdrew. This Dhoba sugar company established a factory at Kotchandpur, in Jessore, getting up English Machinery and afterwards applied the English system to the Dhoba factory also. The history of the English sugar refinery is not a record of success. The truth was, that when they gave a great impulse to the sugar cultivation, native merchants stepped in and appropriated all the trade which the factories had given birth to. The methods used by native merchants impart to the sugar all the purity which is required by the consumers. Had the European market remained open, the European factories might have competed with the native with some chance of success. But the duties levied in Europe appear to have been sufficient to prevent the development of the export trade, and the factories established at Cossipore and Bally, near Calcutta, appear, through the more favourable circumstances in which they were placed, to have monopolised the European market in Calcutta.

556. "The ground chosen for date cultivation is the higher ground, that which is too high for rice to grow well, and the rent paid for such ground is at least three times that for rice land.*

* High and low land, are however equally suitable for date cultivation. In fact date-trees should be grown in small hollows where the rain water would collect and play round them, but too much of it would kill them. Planting should be done 3 yds. apart each way. Pits in which they are planted should be

The trees are planted in regular rows, each tree being about 12 ft. from its neighbour. If so planted and left for 7 years before being touched, good healthy trees may be expected. Those who cultivate dates, keep the land, specially in the cold season, perfectly bare of any vegetation, ploughing up the turf, so that the whole strength of the ground may expend itself in the trees. Of course, there are people who cultivate other crops upon the land where the date trees grow, and there are very many who have not patience enough to wait for the expiration of full seven years; such people, however, lose in the end by their trees failing to give the same richness in juice that is obtained from trees more carefully tended. When the tree is ripe, the process of tapping begins, and it is continued each year thereafter. There are in the date-palm two series, or stories as it were, of leaves; the crown-leaves, which rise straight out from the top of the trunk, being so to speak, a continuation of it; and the lateral leaves, which spring out of the side of the top part of the trunk. When the rainy season has completely passed, and there is no more fear of rain, the cultivator cuts off the lateral leaves for one-half of the circumference, and thus leaves bare a surface measuring about ten or twelve inches each way. This surface is at first a brilliant white, but becomes by exposure quite brown, and puts on the appearance of coarse matting. The surface thus laid bare is not the woody fibre of the tree, but is a bark formed of many thin layers, and it is these layers which thus change their colour and texture.

557. "After the tree has remained for a few days thus exposed, the tapping is performed by making a cut into this

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manured at the end of each season and the ground ploughed up before and after the rainy season until they are fairly well grown up. Each palm before it enters into its full adult stage throws up about 15 to 20 offshoots which may be detached and transplanted. One per cent. of male trees for fecundating purposes would be quite enough. But male and female trees should be grown indiscriminately where obtaining of juice is the only object.

exposed surface, in the shape of a very broad V, about 3 inches across and ¼ or ½ inch deep. Then the surface inside the angle of the V is cut down, so that a triangular surface is cut into the tree. From this surface exudation of the sap takes place, and caught by the sides of the V, it runs down to the angle, where a bamboo of the size of a lead-pencil (*i. e.*, a narrow bamboo channel) is inserted into the tree to catch the dropping sap and carry it out as by a spout.

558. "The tapping is arranged throughout the season, by periods of 6 days each. On the first evening a cut is made as just described and the juice is allowed to run during the night. The juice so flowing is the strongest and best, and is called "*jiran*" juice. In the morning the juice collected in a pot hanging beneath the bamboo spout is removed and the heat of the sun causes the exuding juice to ferment over and shut up the pores in the tree. So in the evening the new cut is made, not nearly so deep as the last, but rather a mere paring, and for the second night the juice is allowed to run. This juice is termed "*do-kat*," and is not quite so abundant or so good as the "*jiran*." The 3rd night no new cutting is made but the exuding surface is merely made quite clean, and the juice which runs this 3rd night is called "*jharna*." It is less abundant and less rich than the *do-kat*, and towards the end of the season, when it is getting hot, it is even unfit for sugar manufacture, the *gur* made from it (and also from day *jharna*) being sold simply as "droppings." These three nights are the periods of activity in the tree, and after these three it is allowed to remain for three nights at rest, when the same process again begins. Of course, every tree in the same grove does not run in the same cycle. Some are at their first, some at their second night, and so on; and thus the owner is always busy.

559. "Since every sixth day a new cut is made over the previous one, it follows that the tree gets more and more hewed into as the season progreses, and towards the end

of the season, the exuding surface may be, and often is, as much as 4 inches below the surface. The cuts are during the whole of one season made about the same place, but in alternate seasons, alternate sides of the tree are used for the tapping; and as each season's cutting is thus above the previous season's, and on the opposite side, the stem of the tree has, if looked at from the side, a curious zigzag appearance. The age of a tree can of course be at once counted up by enumerating the notches and adding 6 or 7, the number of years passed before the first year's notch. When they are 46 years old they are worth little as produce-bearing trees. At first the size of the bared surface previous to the notching, is about 10 inches square; but it gets less and less, as the notches come to the higher and narrower part of the trunk, and I have seen old trees where not more than 4 inches square could be found. It is somewhat remarkable that the notches are almost always on the east and west sides of the tree, and very rarely on the north and south sides; also the first notch appears to be made, by far the majority of instances, on the east side.

560. "As to the produce of one tree, one may expect from a good tree a regular average of 5 srs. per night (excluding the quiescent nights). The colder and clearer the weather the more copious and rich the produce. In the beginning of November tapping has begun. In December and January the juice flows best, beginning sometimes as early as 3 P. M., and it dwindles away as the warm days of March come. If the cultivator begins too early, or carries on too late, he will lose in quality and quantity as much as he will gain by extending the tapping season. But high prices begin in October, and there are not many who can resist the temptation on running into market with their premature produce.

561. "During the whole of the tapping season a good cultivator will keep his grove perfectly clean and free from jungle or even grass.

562. "So much then for tapping. The next process is the

boiling, and this every raiyat does for himself, and usually within the limits of the grove. Without boiling, the juice speedily ferments and becomes useless; but once boiled down into *gur*, it may be kept for very long periods. The juice is therefore boiled at once in large pots placed on a perforated dome, beneath which a strong woodfire is kept burning, the pared leaves of the trees being used among other fuel. The juice, which was at first brilliant and limpid, becomes now a dark brown half viscid half solid mass, which is called *gur* (molasses), and when it is still warm, it is easily poured from the boiling pan into the earthen pots (small *gharras*) in which it is ordinarily kept.

563. "As it takes from 7 to 10 seers of juice to produce one seer of *gur* or molasses, we can calculate the amount of *gur* which one ordinarily good tree can produce in a season. We may count four and a half months for the tapping season, or about 67 tapping nights. These at 5 seers each produce 345 seers of juice, which will give about 40 seers, or 1 mnd. of *gur*. A bigha of grove containing 100 trees will therefore produce Rs.200 to Rs. 225 worth of *gur* if all the trees are in good bearing.

564. "It is not all sorts of pottery which will bear the continuous hard firing required for boiling down the juice and some potters have obtained a special reputation of the excellence of their wares in this respect. The whole of the region about Chaugachha and Kotchandpur is supplied principally from a village, Bagdanga, a little west of Jessore, where the clay seems to be of an unusually good quality. The southern part of the district, again, is supplied chiefly from Alaipur, a bazar near Khulna.

565. "A raiyat, after boiling down his juice into *gur*, does not ordinarily do more; it is then sold to the refiners, and by them manufactured into sugar. Near Keshabpur, however, a large number of raiyats manufacture their own sugar and sell it to the exporters only after manufacture.

There are also in almost all parts of the district a class of refiners different from those who are refiners and only refiners by profession. These are the larger raiyats in the villages, many of whom combine commercial dealings with agriculture. They receive the *gur* from the raiyats in their vicinity, and sometimes also purchase it in the adjacent *hats*, and after manufacturing what they thus purchase, they take their sugar to some exporting mart and sell it there to the larger merchants.

566. "We shall now see what the process of manufacture is. But there are several methods of refining, and two or three sorts of sugar produced. We will take them in order, and describe first the method of manufacturing "*dhulua* sugar—that soft, moist, non-granular powdery sugar, used chiefly by natives and specially in the manufacture of native sweet-meat."

567. The pots of *gur* received by the refiner are broken up and the *gur* tumbled out into baskets, which hold about a maund each and are about 15 inches deep ; the surface is beaten down so as to be pretty level and the baskets are placed over open pans. Left thus for 8 days, the molasses passes through the basket, dropping into the open pan beneath and leaving the more solid part of the *gur*, namely the sugar, in the basket. *Gur*, in fact, is a mixture of sugar and molasses and the object of the refining is to drive off the molasses, which gives the dark colour to the *gur*.

568. "The eight days' standing allows a great deal of the molasses to drop out, but not nearly enough ; and to carry the process further, a certain river weed, called *Shyala*,* which

* This is probably Vallisneria verticillata. All kinds of aquatic weeds going by the name of *Shyala*, other weeds have been sometimes used by mistake in place of V. verticillata, only with partial success. Vallisneria Octandra (*pata-shyala*) and Ceratophyllum verticellatum (*jhanji*) which are occasionally used for this purpose, do the bleaching only imperfectly. The subject needs to be worked up scientifically, as probably it is not merely the continu-

grows freely in the Kabodok especially, is placed on the baskets so as to rest on the top of the sugar. The effect of the weed is to keep up a continual moisture, and this moisture, descending through the sugar, carries the molasses with it, leaving the sugar comparatively white and free from molasses. After eight days' exposure with *shyala* leaves, about 4 inches are cut off and *shyala* applied on the newly exposed surface. This and one other application will be sufficient to purify the whole mass.

569. "The sugar thus collected is moist, and it is therefore put out to dry in the sun, being just chopped up so as to prevent it caking. When dried it is a fair, lumpy, raw sugar, and it weighs about 30% of the original mass, the rest of the *gur*, having passed off in molasses. Dishonest refiners can get more weight out of it by diminishing the exposure under *shyala* weed, so as to leave it only 5 or 6 days, instead of 8. The molasses is less perfectly driven out and the sugar therefore weighs more. Of course, it has also a deeper colour but this is in a measure remedied by pounding under a *dhenki*. There are also other dishonest means of increasing the weight, for example, the floors of the refineries are sometimes a foot or more beneath the level of the ground outside, the difference representing the amount of dust which has been carefully swept up with the sugar when it is gathered up after drying. Also, it is very easy to break the pots so that fragments of them remain among the sugar.

570. "The first droppings, gathered in the open pan in the manner described above, are rich in sugar, and are used, especially in the north-west, for mixing up with food. It entirely

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ous presence of the moisture gradually washing away the glucose that is so effective in making brown-sugar white. The author has tried bleaching the *gur* by keeping over it wet sponges, but failed, and he has found the Vallisneria verticillata possessing the bleaching property in a more marked manner than the other aquatic weeds mentioned above

depends, therefore, upon the price offered for them for the purpose, whether they are sold at once or reserved for a second process of sugar manufacture. In this second process the first droppings are first boiled and then placed under ground in large earthen-ware pots to cool. Unless thus boiled they would ferment but after being boiled in this fashion they on cooling form into a mass somewhat like *gur*, but not nearly so rich. After this, the previous process is again gone through, and about 10% more weight in sugar is obtained. This sugar is, however, coarser and darker in colour than the first.

571. "The refiner is not very honest and if he is sure of finding immediate sale, he will use a much more speedy process. Taking the cooled *gur* he will squeeze out the molasses by compressing the mass in a sack, and then, drying and breaking up the remainder, will sell it as sugar. It does not look much different from that prepared in the more elaborate fashion, but it will likely soon ferment and hence the necessity of finding an immediate purchaser.

572. "The remainder, after all, this sugar has been squeezed out, is molasses, *chitiya gur* as it is called. It forms a separate article of commerce.

573. "The sugar produced by the method just described is called *dhulua* sugar, a soft, yellowish sugar. It can never be clean, because it is clear from the process used, that whatever impurity there may originally be in the *gur*, or whatever impurity may creep into the sugar during its somewhat rough process of manufacture, must always appear in the finished article. Another objection to it is, that it leads slightly to liquefaction, and cannot therefore be kept for any considerable time.

574. "The *'pucca'* sugar is a much cleaner and more permanent article. It has also a granular structure, which the *dhulua* has not. The manufacture of it is more expensive than of the other, and the price of it when finished is about Rs. 10, whereas *dhulua* costs only about Rs.6 per mnd.

575. "In this process the *gur* is first cast upon flat platforms, and as much of the molasses as then flows off is collected as first droppings. The rest is collected, put into sacks and squeezed, and a great deal of the molasses is thus separated out. The sugar which remains behind is then boiled with water in large open pans, and as it boils, all scum is taken off. It is then strained and boiled a second time and left to cool in flat basins. When cool it is already sugar of a rough sort and now *shyala* leaves are put over it, and it is left to drop. The result is good white sugar, and should any remain at the bottom of the vessels still unrefined, it is again treated with *shyala*.

576. "The first droppings, and the droppings under *shyala* leaves, are collected, squeezed again in the sacks, and from the sugar left behind, a small quantity of refined sugar is prepared in exactly the same way, by twice boiling. The droppings from the sacks are *chitiya gur*, and are not used for further sugar manufacture. About 30 per cent. of the original weight of the *gur* is turned out in the form of pure *pucca* sugar.

577. "There remains to be described the English process of refinement used in the factories of Kotchandpur and Chaugachha. In this, the raw material is mixed with a certain amount of water and boiled in open cisterns, the boiling being accomplished, not by fire, but by the introduction of steam. The lightre filth now floats to the surface and is skimmed off, while the boiling solution is made to flow away through blanket strainers into another cistern. After this it is boiled to drive off the water. Now, if the mass were raised to boiling temperature, the result would be sugar, granular indeed in structure, but not differing in this respect from native *pucca* sugar. But if the water be driven off without raising the mass to boiling point, then we get the crisp and sparkling appearance which loaf-sugar always has. Whether there is any difference in the substances, I do not know, but so long as

people prefer what *looks* pleasant and nice, sugar of this sparkling appearance will command a higher price in the market.

578. "The object is attained by boiling in a vacuum pan, that is to say, a large closed cistern from which a powerful pump exhausts the vapour as it rises. The lower the atmospheric pressure on the surface of any liquid the lower the temperature at which ebullition takes place. The pump is therefore regulated so as to diminish the pressure on the surface to meet a point that the mass will boil at about 160° F. and the apparatus being kept regulated to this point, all the water is driven off by boiling by means of introduced steam, without the temperature becoming higher than 160°.

579. "It is out of place here to describe the mechanical devices for filling and keeping filled and employing and watching and testing the liquid within the closed cistern, or for regulating the supply of heat and the action of the pump, which is driven by steam. It is sufficient to pass at once to the end of the vacuum pan stage, which lasts 8 hours, and to say, that the mass in the pan is now run off into sugar-loaf moulds, which are placed up side down, having a hole in their vertex, placed above a pot. The molasses by its own weight drops out by this hole and is caught in the earthenware pot beneath.

580. "The last of the molasses is washed out in the following manner. The uppermost inch of the sugar in the mould is scraped off moistened, and put back. The moisture sinks through the mass and carries with it the molasses. This is done some three times and then the sugar having now been 12 days in the moulds, the purification is considered to be finished, and the loaves may be turned out of the moulds. If the raw material used was the *gur* as it comes from the cultivator, the result is a yellowish, sparkling loaf-sugar, but if native refined *dhulua* sugar is the raw material used, than the loaf is of brilliantly white sugar.

581. "The process used at Cossipore, near Calcutta, is similar to last described. The principal difference consists in this, that the sugar is at one stage additionally purified by being passed through animal-charcoal, and that the molasses, instead of being allowed to drop out by its own gravity from the moulds, is whirled out by the application of centrifugal force."

582. *Chitiya gur* is used for mixing with tobacco, and the cleaner and sweeter molasses for preparing cheap native sweets out of fried and parched rice and pop-corn. There is considerable demand for *chitiya gur* and molasses in India, as about 18,000 tons of molasses are annually imported into this country from Mauritius alone.

583. A most interesting experiment has been undertaken by the Khandwa Sugar Manufacturing Company in the manufacture of date-sugar in the Central Provinces, and as the author of this Hand-book has been associated with this experiment, he is able to furnish the latest figures, which differ somewhat from those given by Mr. Westland, but the conditions of the Jessore and the Central Provinces date plantations are entirely different, and the following figures are not by any means intended to discredit those supplied by Mr. Westland, but rather to supplement them.

584. In the Khandwa experiments, for every circle of 5,000 trees, 30 *Seolis* or professional juice-collectors and 10 labourers are employed, the former being paid Rs. 12 and the latter Rs. 6 per month. The tapping and *gur*-making season lasts for four months and the expense per circle of 5,000 trees, is, therefore, $4 \times (30 \times 12 + 10 \times 6) =$ Rs. 1,680. Extra expenses come to about Rs. 220, making the total Rs. 1,900 per circle.

585. The average produce of juice per tree is 3 seers per day for the days in which they are tapped. In the Khandwa experiment, 4 days of rest are allowed after 2 days of tapping and even then the yield of juice per tree comes to only

6 seers for 6 days (including the quiescent days). Each *seoli* takes up a circle of 120 trees, 40 going to a *mahal* or section, and the 120 trees are thus divided into three sections. After taking the *jiran* and *do-kat* juice on each *mahal*, he goes on to the next *mahal*, and so on to the third, returning to the first *mahal* after giving it rest for 4 days. Each tree is tapped about 40 times during the four months, and the produce of juice per tree is therefore 120 seers or 3 maunds, and the 30 *seolis* are able to gather $30 \times 120 \times 3$ maunds of juice. As about 8 maunds of juice go to make 1 maund of *gur*, the annual yield of *gur* per circle is $\frac{30 \times 120 \times 3}{8} = 1{,}350$ mnds. the money value of which is about Rs. 4,000. The net profit per circle is therefore nearly Rs. 2,000 per annum.

CHAPTER LXV.

SUGAR.

SUGARS may be classified under two groups,—glucoses and sucroses. Honey is a glucose, consisting of two constituents, dextrose ($C_6 H_{12} O_6 H_2 O$) which is the more solid portion, and lævulose ($C_6 H_{12} O_6$) which is the more liquid portion. Cane-sugar ($C_{12} H_{22} O_{11}$) and maltose ($C_{12} H_{22} O_{11}$) come under sucrose. Dextrose occurs also in grapes, and in many juices of plants and it is therefore called grape-sugar. It reduces alkaline solution of cupric hydrate giving a red precipitate of cuprous oxide ($Cu_2 O$), while cane-sugar does not do so unless it is first heated with a dilute acid. This reaction is made use of in estimating the amount of dextrose present in liquids. All sugars are soluble in water and less so in alcohol. Lævulose resembles dextrose except

in its action on polarized light. Dextrose rotates the plane of polarized light to the right hand and lævulose to the left hand. Dextrose and lævulose are not so readily crystallized as cane-sugar is, and the molasses of cane-sugar and other raw sugars contain dextrose and lævulose. These Glucoses being hygroscopic substances absorb moisture from damp air, which accounts for *gur* and *dalua* sugar running in the rainy season and good Cossipore Factory sugar remaining dry. Impurities in the form of Glucoses and ash constituents prevent crystallization of cane-sugar more or less. One part of glucose prevents 1 part of cane-sugar from crystallizing and one part of ash prevents 5 parts of cane-sugar from crystallizing. Unripe cane, maize-stalks and sorghum-stalks contain less cane-sugar and more glucose. A properly ripe cane contains about 80 per cent. of water, 16 per cent. of cane-sugar, ·3 per cent. of glucose, ·75 per cent. of ash, and about 3 per cent. of albuminoid matter.

587. Beume's Saccharometer is graduated to indicate the amount of sugar in a saccharine solution, each degree on the scale representing 0·019 per cent. of sugar, so that a liquor registering 10° would contain 1·9 per cent. of sugar. Syrups when hot are about 3 degrees lighter than when cold and the Saccharometer is standardised at 84° F. In clarifying and in boiling sugar-cane juice the use of a copper-case thermometer is essential. One registering from 0° to 300° F. is the best to use.

588. Dilute acids convert cane-sugar into a mixture of dextrose and lævulose. Cane-sugar rotates the plane of polarized light to the right and a mixture of equal parts and dextrose and lævulose to the left. Sugar is therefore said to be 'inverted' by dilute acids. Sugar-cane juice is naturally somewhat acid and hence in the boiling process some cane-sugar is inverted into glucose. The only dilute acid which does not invert the sugar liquid is Phosphoric acid; hence this acid is used along with milk of lime in clarifying the

liquid. The addition of slaked quick-lime for neutralizing the juice before boiling, is of the highest importance. But just sufficient lime should be added to neutralize the acid or else the colour of the sugar produced will be too dark.

589. Maltose is produced naturally in germinating barley. Germinating barley dried and digested with water at about 60° C, parts with its malt-sugar which can be obtained from the solution by boiling it down.

590. The difference of action of polarized light on different kinds of sugar is a principle utilized in factories for testing the purity of sugar or sugar-cane juice, with the help of an instrument called polariscope. It consists of two prisms of transparent calcite (Iceland spar) enclosed in a tube, between which the saccharine solution is introduced. Light passing through the outer prism, the saccharine solution and the inner prism, traverses a layer of transparent quartz so adjusted that the rotation caused by the sugar-solution can be detected and measured. The rotatory power of cane-sugar is 73·8° to the right and it may be found out by observing a column of saccharine solution 1 decimetre in depth containing 1 gramme of pure cane-sugar in every cubic centimeter of fluid. To get the rotation of any sample from this observed rotation divide the former by the depth of the column of fluid multiplied by the weight of the sugar in each cubic centimetre of liquid. Thus, if a solution of 0·25 gram of sugar in each C. C. of fluid has an observed rotation of 25° in a column 2 decimetres in depth, the rotatory power of the sample is $\frac{25}{2 \times 0{\cdot}25} = 50°$. The percentage of cane-sugar in the sample would thus be $(73{\cdot}8 : 50 :: 100 : x)$ $\frac{100 \times 50 \times 10}{738} = 6{\cdot}77$. If no invert-sugar is present, the proportion of sugar present in the juice or solution can be found by multiplying the rotation of the solution as observed by polarscope by 100 and dividing the product by 73·8.

591. The presence of invert-sugar is detected by the copper test. Cane-sugar does not give the characteristic red precipitate of Suboxide of copper (Cu_2 O) from alkaline solutions of cupric tartarate, while glucose does. To estimate the proportion of glucose present, a standard solution is used. This is Fehling's solution. It consists of 90½ grains of sulphate of copper, 364 grains of neutral tartarate of potash, 4 fluid ounces of caustic soda of specific gravity 1·12 and water to make up 6 ounces. In using this standard solution it is brought to the boiling point and a known weight and volume of solution of glucose dropped into it from a burette until the copper has been just reduced which is known by the blue colour being destroyed. The precipitate is then filtered dried and weighed, the difference between its weight and that of the sugar used in the solution gives the percentage of cane-sugar. The quantity of sugar lost in reducing the copper being glucose the residue is sucrose. Fehling found that one equivalent (180 parts) of glucose decomposed 10 equivalents (1246·8 parts) of sulphate of copper. Therefore the percentage of glucose in the sugar solution =

$$\frac{\text{weight of the sugar solution} \times 100}{\text{wt. of the soln. reqd. to reduce copper} \div \text{wt. of sugar used}}$$

and the percentage of cane-sugar = weight of sugar used *minus* percentage of glucose. Lactose behaves in the same way as glucose with respect to Fehling's solution.

592. A new process of refining brown-sugar (*i.e.*, muscovado) has been invented by M. Robin Langlois, a French Engineer. Cane and beet sugar of the whitest and best quality can be made by this process, which is still a secret. The principal advantage of this system is that it is very quick.

593. Sugar is not made only from date-palm juice, sugar-cane and beet. It is also obtained from maize-stalks, stalks of sorghum saccharatum, cocoanut and toddy-palm juices, and Bassia butyracia. In America the maple-tree is largely

tapped for a sugar-yielding juice. Coal-tar from which so many fine dyes and other articles of economic value are obtained, is the source of a highly sweet substance called saccharine. One tabloid of saccharine scarcely so large as a two-anna piece, will sweeten a cup of tea. But this substance has no feeding value like genuine sugars. Milk is also a source of sugar. After cream and cheese have been extracted out of fresh milk, the whey from the cheese-vat is forced into a large boiler whence after a time the liquid is run into an evaporating pan, where the boiling is continued until a thick syrup is formed. This syrup is left standing for a time and again boiled when the sugar forms. The sugar is pressed and the molasses rejected, and then packed in barrels for the refinery. The process of refining raw-sugar from milk is also a secret.

594. Beet-sugar is largely manufactured in Germany and Austria, and it is competing very successfully with cane-sugar. Good roots of beet yield on an average $\frac{1}{8}$th of their weight of sugar, but $\frac{1}{6}$th has been also obtained of late years. The proportion of sugar is materially increased by phosphatic manures and by selection only of *middle-sized roots* for seeding. Middle sized roots (which are white) are also grown for crushing for sugar. In 1876 the average produce of sugar from an acre of beet (*i.e.*, from 10 tons of roots) was estimated at 2,000 lbs., while in 1896 the average rose to 3,000 lbs. per acre, and the tendency is towards further amelioration. It should be noted however that 3,000 or 4,000 lbs. of sugar per acre is considered a poor yield for sugar-cane, and 8,000 lbs. or even more are often obtained. Though chemists have not been able to find any difference between cane-sugar and beet-sugar, manufacturers do not consider them identical. For the condensed milk trade beet-sugar has been found altogether unsuitable.

595. The Superintendent of the Saharanpur Botanical gardens has made an interesting experiment on the cultiva-

tion and manufacture of beet sugar. He came to the conclusion that the white sugar beet can be easily introduced as a cold weather crop in India. The pressure was not applied directly to the roots as in the case of sugar-cane. The roots were washed clean of earth, the tops and tails cut off, and the roots sliced and pulped. This pulp was put on a piece of calico and strained and afterwards pressed. The juice was strained a second time and then clarified and boiled like sugar-cane juice. The cost of cultivation came to only 8 pies per pound of *gur* obtained and the cost of manufacture to 2 annas and one pie per 1lb. As no pulping machine was used but the roots were pulped by a hand-grater somewhat like a nutmeg-grater, the cost of manufacture was excessive. The cost of cultivation per acre came to Rs. 61-8 as. and the total value of raw sugar at Rs. 4 per maund came to Rs. 71-10 as. per acre. The yield per acre was 9½ tons of roots, 6 tons of green leaves, 4½ tons of juice, and 13 cwts. of *gur* of which about half the quantity may be put down as pure cane-sugar. Mr. Proudlock of the Ootcamond Botanical Garden also reports favourably of sugar-beet growing.

596. With regard to the manufacture of sugar by a scientific process, the following general summary may be remembered :—

(1) The first object after the juice has been obtained in the fresh state either from beet, sugar-cane, maple, or palm is to remove the albuminoid substance, which acts as a ferment and turns sugar acid. Acidity 'inverts' cane-sugar and prevents proper crystallisation. The ash or non-saccharine substances also prevent crystallisation. Hence the great importance, of clarifying before boiling. The temperature of the juice at clarifying should be between 125° and 145°. In any case it should not be allowed to go above 160° F.

(2) The clarifying is done by adding to the hot cane juice just enough of slaked lime by stirring which would neutralize the juice which is naturally acid. The albuminoid matter

combining with lime sinks. For clarifying, about ½ a tola of slaked lime per *ghara* of juice will be found ample. Thus clarified and neutralized the juice should be filtered in double flannel bags and then boiled, the impurities floating as scum on the boiling mass being taken off. When thick, the brown sugar is put in casks or earthen pots in which holes are afterwards made to get rid of the molasses.

(3) To get rid of the molasses more quickly and thoroughly it is advisable to use a sugar-turbine. A hand sugar-turbine or centrifugal machine is sold by Messrs. Mylne and Fox of Beheea for Rs. 200. When the molasses have run out brown crystals are left behind. These are mixed with warm water into a syrup, lime is added to it, and the mixture is poured into bags made of thick woollen cloth and left to drip through into a vessel below. The liquid though clean is still coloured, and it is made colourless by passing it through a bed of bone-charcoal. This colourless syrup is then put in large copper pans and boiled. When thick enough it is poured into moulds after which we get loaf sugar. The moulds are placed with their small pointed end downwards. Here there are some small holes. Part of the syrup which does not harden flows out into a vessel underneath. This is called 'golden syrup.'

597. Evaporation in a vacuum apparatus, which results in more sparkling crystals, and the separation of molasses by a centrifugal apparatus, are the two specialities of the factory system as distinguished from the cottage system of making sugar, but the Indian cottage system of making raw sugar may be improved. If the preliminary neutralizing and clarifying of the sugar-cane juice is very carefully done, and aluminium vessels or earthen *handies* used, the second filtering through bone-charcoal will not be found necessary. Any excess of lime tends to make the sugar brownish grey in colour, but if phosphoric acid diluted very much with water is first added to the juice and the heating never allowed

to reach the boiling point, after the lime has been gradually added by stirring, there should be no lime left in the clarified liquor. Lime is not altogether insoluble in water ; but with phosphoric acid it forms an insoluble compound which is bound to get precipitated. Naturally there is some glucose present in cane-sugar. This is got rid of by treating the *gur* (after it has been boiled and crystallized) to a few rounds of the turbine. A slight modification of the native system of *gur*-making may be thus employed in obtaining white sugar, good enough for all ordinary use.

598. At Sibpur, we found *gur* made by clarifying as above can be easily divested of molasses by simply drilling a hole at the bottom of each *kalsi* or pot of *gur*. The residue in the *kalsi*, spread out in the sun for a day, then powdered fine in a *dhenki*, and then again spread out in the sun for two days, is good white sugar, which will be accepted as sugar at least in the native market. It is highly desirable to introduce this very simple method of making sugar among native sugar-cane cultivators of India. A sample of the sugar made by this process has been sent by the writer of this Hand-book to the Economic Section of the Indian Museum for exhibition (Registered No. 15085—3).

599. The Sibpur experiment with a view to obtaining as good sugar and *gur* as were obtained from sugar-cane juice, from the juice of the date-palm, proved a failure. The failure is probably attributable to the fraud practised universally by the sellers of date-palm juice in Calcutta and its neighbourhood. They adulterate the juice with a very large proportion of water and to sweeten the mixture they add some date-*gur* molasses. Such a mixture of molasses and water with a small proportion of cane-sugar, cannot be expected to crystallize properly.

CHAPTER LXVI.

SUGAR-CANE (SACCHARUM OFFICINARUM).

THIS plant is indigenous to India, and it yields a higher proportion of sugar than any other, beet coming next to it, and the date-palm after beet. The maple-tree of America may be regarded as fourth in importance.

601. *Foreign canes.*—Though indigenous to India, the best varieties of sugar-cane are now found in those countries where European and American planters have been employed in its cultivation. Even the Chinese cane, called by Dr. Roxburgh Saccharum Chinensis, is said to be a better yielder and hardier than the Indian canes. The best varieties of Mauritius canes are the Big Tanna, Port Mackay, Lousier, Iscambine, Bamboo, and Bois Rouge. The best Queensland cane is the Rappoe or Rose Bamboo, which is a very hardy variety, though yielding the largest proportion of cane-sugar. In the Strait Settlements the Striped Bourbon and Yellow Mauritius are considered the best canes, though for chewing purpose the Otaheite is preferred to all others. For weight and length the Tanna variety excels the others. Of good seedling canes may be mentioned white Bamboo, Singapore, Bourbon and Demerara. The standard cane of the Barbadoes is the White Transparent; but a seedling cane lately established excels this and all other good varieties of canes grown in Barbadoes, such as, the Bourbon, the Jamaica, and the Queensland Creole. The White Transparent yields about 5,400 lbs. of *gur* and 4,500 lbs. of cane-sugar per acre in lowlying black soils. The Bourbon cane, which yields very good result on high red soils, gives only, 1,000 lbs. of *gur* and 840 lbs. of cane-sugar per acre grown on lowlying black soils. The seedling cane which has been lately established in

Barbadoes (which has been named 'B 147') suits both high and low soils, its average yield being 6,765 lbs. of *gur* and 6,291 lbs. of cane-sugar per acre. The average obtained on low-lying black soils is still higher.

602. *Indigenous varieties.*—The names of the indigenous varieties of sugar-cane are very numerous, but they do not necessarily indicate distinction. Their habits must be closely studied before they can be classified into distinct groups. The following varieties have been grown at the Sibpur Farm, —Samsara, Bombay, Khari, Chittagong Patnai, Saharanpur, Poona, Dhalasundar, Mongo, Malohi, Puri, Bagdia, and Baghi. Of these, Chittagong Patnai, Samsara, and Khari sugar-canes have been found to be the best. The first two are good chewing varieties, and the last a very good variety for planters to grow, as it is thick-skinned, and not so subject to the attack of jackals and insects and it is a free ratooner. After four years the yield falls off rapidly, and as it is not safe to keep sugar-cane growing on the same land for more than 3 or 4 years, the ratooning should not be carried on beyond the fourth year, after which insect and fungus pests predominating, the crop becomes a source of infection to the neighbourhood. The Chittagong Patnai variety though producing fatter and longer canes, is very much more subject to the rind fungus than the Samsara or other Bengal varieties. On the whole, therefore, it is best to grow Samsara, if the attention and care necessary for growing a superior variety can be bestowed, or else to grow the Khari cane. For low-lying *bil* lands, which remain under 3 or 4 ft. of water for a month or more, a variety of canes known as *Kulerá* or *Jali-ák*, in Faridpur, can be grown. The straw-cane and the grass-cane of Bombay, and the red sugar-cane of Assam are also suitable for swampy lands. Besides the Samsara and the Chittagong Patnai sugar-cane, other superior chewing canes are the Madrasi Paunda of the N.-W.P., the Bombay, the Poona, Shaharanpur sugar-cane and the Dhalasundar cane of Dacca. The Chinia

or Chini cane of Bhagalpur and Patna is another good chewing variety. In some districts of Western Bengal a hardy variety of sugar-cane known as Uri, sends out arrows and seeds very freely. Other hardy varieties, suitable for agriculturists are Kajli, Puri, Katari. The Puri variety grown in Orissa Division produces canes somewhat more slender than those produced by the Kajli variety which is grown by cultivators all over Bengal. The canes of both these varieties are somewhat thicker than Khari canes, but they are not such free ratooners nor can they stand water-logging so well as the Khari, though like the Khari they can be grown without irrigation. The chewing canes make better jaggery than the hardier varieties. The Samsara cane makes the lightest coloured jaggery, though the crystals are somewhat smaller than the crystals of the jaggery or *gur* made from Bombay or Khari Sugar-cane.

603. *Yield of gur.*—The average yield of *gur* under a proper system of cultivation and manuring such as is practicable on a large scale by planters, can be put down at 4,000 lbs. per acre, though as much as 8,000 lbs. per acre, are sometimes obtained. From Samsara and other superior varieties, by very careful cultivation and high manuring 8,000 lbs. per acre may be often obtained, but from Khari and the hardy varieties 4,000 lbs. of *gur* per acre can be obtained at a comparatively small cost. The average produce of *gur* per acre of the whole country has been estimated at a ton (2240 lbs.) per acre, and the maximum yield obtained by cultivators is 4 tons.

604. *Sugar-growing localities.*—The area under sugar-cane in the whole of India has been estimated at 2,800,000 acres, and in Bengal at 900,000 acres, *i. e.*, about 1·5 per cent. of the cultivated area of the provinces. On the basis of 1 ton per acre, we have about 10 crore maunds as the annual produce of *gur* in India, while the import of sugar per annum is about 50 lakh maunds. Mauritius supplies the largest proportion of sugar imported to India. Besides sugar there are about 5 lakh

maunds of molasses imported annually from this island. Considering the proportion between the quantity of sugar imported into the country and the vast quantity actually produced, it cannot be said there is much room for expansion of this industry. A slightly increased local produce, the general introduction among cultivators of the knowledge of making white sugar (good enough for all ordinary use), and some improvement on the existing position of the European sugar factories in India, may altogether kill the import trade in sugar, which though large, is relatively not so. By instituting improvements in the cultivation and specially in the manufacture of sugar, in the principal sugar-cane-growing localities of India a vast impetus can be given to this industry. Such encouragement can have but one result, the lowering of prices of the raw article while the raw article itself will be of a very superior quality, that is, to all intents and purposes sugar, and not *Gur*. If the European sugar factories in India can secure such *gur* at a cheap price, they can not only stop the import of beet and other sugars, but actually invade the markets of Europe and America. In Bengal, the districts where the art of making a superior raw-sugar can be taught are, Rangpur (with nearly 5 per cent. of its cultivated area under this crop), Pabna, Darbhanga, Bhagalpur, Manbhum (with 6½ per cent. of its cultivated area under this crop), Saran, Faridpur, Mymensingh, Hazaribagh, Shahabad, Dacca, Gaya Dinajpur, Muzufferpur, Burdwan and Backergunge. Each of these districts has more than 20,000 acres under sugar-cane.

605. *Soil.*—The enumeration of the principal sugar-growing districts in Bengal, should lead one to infer, that all kinds of soils answer for growing sugar-cane, the rough archæan soils of the Chhotanagpur Division, the old alluvium of Bihar, and the new alluvium of Eastern Bengal. The best canes grow at the junction of old and new alluvia on the sides of streams and rivulets. These are red clay loam soils specially rich in mineral matters. For growing the superior varieties

of cane, the two principal considerations that should guide one in the selection of a site are: (1) Is the land close to water from which it can be easily irrigated? (2) Is the land above inundation level and easily drained and yet level. Some red soils of Burdwan, Birbhum and Kandi Sub-division of Murshidabad, though very light, are highly valued for growing sugar-cane. Probably they contain a high proportion of phosphorus. Phosphates are greatly valued for manuring sugar-cane wherever European and American planters have taken to growing this crop. A very large proportion of the bones collected for export in India, goes to the sugar-cane plantations of Mauritius. If our cultivators will not use bones, they can at least prevent their being collected and taken away from their fields and from village golgothas. They do some good even when they lie about in the fields in a neglected condition. A phosphatic mineral called apatite has been discovered as a bye-product of mica mines in the Koderma forest of Hazaribagh. This mineral powdered up is being sold by Messrs. Ewing & Co. of Calcutta at Rs. 3 a maund. It is quite worth this price for the sugar-cane crop. Applied once in 5 years at the rate of 10 maunds per acre, it should keep up the supply of phosphates which is so essential for this crop. Of course, the effect of such an insoluble manure as apatite, even when it is used in a powdered state, must always remain imperceptible, unless an invigorating manure, such as Sulphate of ammonia or Saltpetre, is used also; but as an improver of the soil for the sugar-cane crop, apatite is of the highest value, unless analysis shows the soil to be already very rich in phosphates, say, containing ·05 to 1 per cent. of phosphates. If a soil contains less than ·05 per cent. of phosphates and if such soil is used for growing sugar-cane, it will be benefited by the occasional application of bone-dust or apatite. Even those hardy varieties of sugar-cane that can stand drought and inundation and for which any soil seems to answer, ought to have phosphatic manure applied to them in addition to cattle-

dung, oil-cake, saltpetre, or other manure that may be used. Where the land is annually renovated by silt, and where such land is utilised for growing an aquatic variety of sugar cane, no special manuring, is needed, or will be of much use.

606. *Seedling canes.*—New and hardy varieties of canes are obtained by Dutch planters in Java and elsewhere by a laborious and costly process of selection. The following directions for growing sugar-cane from seed are given by the Dutch firm of Messrs. Erdmann and Sielcken of Samarang, Java :—

"The capacity of producing fertile seed is not confined to some single varieties of sugar-cane. Every variety examined up to now, could produce germs though some varieties yield more and stronger seeds than others. One of the chief difficulties in sowing cane is to cut the 'arrow' just at the time of its seeds being ripe and not yet blown away by the wind. The criterion is found to be the topmost leaflet of the cane, just under the arrow. As soon as this begins to wither the seed is ripe and the arrow should be cut. The separate small ears are stripped and laid flat in a wooden box, filled with a mixture of sand, clay and well-rotten penmanure. The ears are not to be covered with earth and the box should be placed in the sun-shine and kept constantly moist by watering it with a common watering pot having a very fine rose in order not to disturb the minute seeds.

"After 5 to 7 days the seeds will germinate and small plants just like young grass, will come forth.

"In order to watch the growth of the young germs, it is good to place a mark near every one, which enables one to find them back easily.

"If after eight days the arrow did not yet germinate, it is a sign that the seed was not fertile, as beyond that time no more germination will take place. As soon as the young plants have reached a height, of 3 to 4 inches they are transplanted in big flower pots, filled with the same soil-mixture as referred to above. The pots are placed in the full sun-

shine and kept constantly moist, as the plants require a rich soil, much water, and much sunshine. After a few weeks, when they are 1 to 1½ feet high they are brought over into the field and treated just as ordinary sugar-cane.

"According to Benecke's and Soltwedel's researches sugar-cane seed loses its germinating power within 6 weeks. Therefore everything has to be prepared beforehand in order to allow the sowing to be started immediately after the arrival of the seeds.

"It ought to be well understood that the only purpose of sugar-cane sowing is the raising of a new variety with possibly better qualities than the ordinary existing ones and not the change of the old way of planting with tops into planting from seed.

"From the thousands of young plants raised in the horticulturists' nurseries, only those are picked, which look promising; the others are destroyed. The picked plants are tested and if some of them prove to be of superior quality they are propagated in the usual way by cuttings.

"The few planters in Java, who have their estates partly or entirely under seedling canes, do not sow their estate, but plant it with cuttings from canes, the ancestors of which have been raised from seed."

607. *Cuttings.*—Canes that are chosen for seed, that is for cuttings, should be 'topped' when they are mature; in other words, the topmost bud should be cut away, that the nourishment may flow to the lateral buds and develope them to a sprouting condition. The sprouting is helped in this country by keeping the cuttings in a cool pit, by putting a layer of damp straw and ashes at the bottom of the pit and then arranging on this successive layers of cuttings and wet straw and ashes until the pit is filled, when over the last layer of ashes and straw, earth is put on, and the whole allowed to remain for a week. After this, the cuttings will be found to have sprouted and rootlets come out of the knots. The cuttings though ready

for planting out may yet be kept for a month if the covering of earth is removed from the pit, and the cuttings kept in a standing position in the pit with a covering of straw and ashes, which should be kept damp by sprinkling of water as occasion arises. The top two feet of canes make the best cuttings, but the topmost bud must be rejected as already directed. The practice prevalent in most parts of India of utilising for cuttings the very topmost portion only is based on a false idea of economy. If topping is done there is no difficulty in selecting the most promising cuttings for planting. In any case, that is, whether topping is done or not, the healthiest and best canes should be chosen for seed, and the top two feet of these used. As the bud occurs on the upper side of a knot and the nourishment is derived from the portion of the cane above this knot and below the next knot above it, cuttings should be so made that there may be no superfluous cane below the lowest node and that a whole joint above the highest bud may be included. Each cutting need not have more than three buds, and if they are made after sprouting has taken place subsequent to topping, one can be almost sure of three buds going to every cutting. With regard to the sprouting of lateral buds either in the cane while it is still standing, or after planting the whole cane in the soil, it should be noted that the topmost bud of the cane sprouts first, then the next one below it, and so on towards the lower end of the cane. But if the cane is cut up into sections and planted, every bud at the upper end of each cutting will come out first simultaneously, and then the next ones towards the thicker end, and so on until the third or fourth bud, *i.e.*, as many as are left on each section, finishes sprouting. So although the planting of cuttings along a line is almost continuous, whole canes, or sections which are too long should not be planted, but to make sure of at least one healthy and uninjured bud per cutting, it is best to have each cutting about 9 inches long.

608. *Planting.*—Sugar-cane harvesting and sugar-cane planting can proceed for eight months in the year, *viz.*, from September to April; but the best time for harvesting sugar-cane are December to February, and the best month for planting the cuttings is February. Harvesting and planting in September and October, one gets very high price for the canes during the Pujahs, and sprouting of the cuttings also takes place freely at this season, as the heat and moisture are both sufficient to help the growth of the young plant. But the cold weather that follows retards the growth, and makes the nodes of the canes very short. From November to May as many as twelve irrigations may have to be given to keep the plants in proper condition. From February the growth is again normal and there are no short nodes formed, but, on the whole, the time and expense from September to February are wasted, and the only advantage in doing the planting in September or October is the obtaining of a crop of chewing canes during the Pujahs when they fetch a very high price in a town like Calcutta. Planting in November to January, the sprouting is most tardy, and most of the cuttings perish before they have time to sprout through the attack of white-ants or from the caking of the soil preventing the sprouts from forcing their way upwards. Cuttings planted from November to January do not make any more progress than those planted in February. If harvesting is done in December and January which months are as well suited as February for making high class *gur*, the seed-cane may be topped and left to sprout on the fields, or they may be made into cuttings and stored in pits, in the manner described before. The actual planting should be put off till February. By planting in March one saves one irrigation, but the growth from cuttings planted in February is better. Of course, the conditions as to temperature prevailing in the delta of the Ganges are not the same as those prevailing in the hills, or in the rocky western districts of this Province. But the principle of planting in

mild temperature and after the cold weather has well passed off, but a good while before the rains set in, may be followed in every locality. Planting in May or June is very risky, except in free and rocky soils, as water-logging or even heavy rainfall, when the plants are still very short, is injurious to most crops. Sugar-cane, like maize or *juar*, is benefited by heavy rainfall if it commences after the plants are about a foot high.

609. Various *modes of planting* are adopted. In Mauritius where high winds prevail, planting is done in deep trenches or holes to give the canes a good support at the base. After the land has been ploughed up, holes or trenches are made about a foot deep, and 4½ to 5 ft. apart from centre to centre. Three inches of loose soil is put in the holes or trenches, and these are watered, and then the cuttings are planted and another three inches of earth put on. When the plants are a foot high, the land is levelled that is the trenches are entirely filled up, and a second earthing makes shallow trenches between the rows of plants.

610. In Bengal, the cuttings are planted in shallow trenches (about 6 inches deep) made with *kodalies*, 2 feet apart. This is much too close planting, involving the use of *kodalies* for hoeing, earthing and trenching. The system prevalent in Queensland, New South Wales and Fiji Islands, seems worth adopting in this country. The cuttings are planted in double rows, 6 feet apart, the two rows close together being only 18 inches apart. This is equivalent to planting single rows 3 ft. apart. But a distance of three feet from centre to centre of lines of plants does not allow interculture by bullocks; while a distance of 6 feet from centre to centre does allow of such interculture being practised. In working on a large scale the employment of hand-tools should be avoided as much as possible, and bullock-power substituted. The trenches may not be so straight, there may be some injury done by bullocks treading on

plants, but these are not of much consequence, as the saving of labour and time effected by the employment of proper farm-implements instead of garden-tools, is enormous. The 18″ trenches can be made with the Double-mould-board plough, the cuttings planted length-wise in two rows at the two sides of the trenches, say 3 cuttings being planted in every 4 ft. of length in each row, and the trenches after irrigation being filled up by splitting of the ridges in between with mould-boards. The subsequent hoeings and earthings can be done with the Hunter hoe, when the planting is done in the above described manner. Planting in this way, nearly 12,000 cuttings are required per acre (theoretically 10,890) and as Bengal cultivators use about 2 *kahans* (2 × 1280) of cuttings per bigha (⅓rd of an acre), there is really not much sacrifice of space made for effecting saving in the cost of labour. The growth of canes is also healthier under such a treatment, as the plants get more air and sunlight throughout the period of growth and a proper elaboration of sugar is the consequence.

611. The proper time for sowing of sugar-cane seed is June, but if the arrows appear earlier in the season and the seeds mature in March or April, sowing must be done within a month after the seed is gathered. The soil must be kept constantly moist and only just moist throughout the period of germination and growth of seedlings. The transplanting of seedlings into boxes or pots and afterwards into fields should be done in the manner already described. The seedlings when 1 to 1½ ft. high are ready for transplanting into the fields. This should be done during the rainy season, and the planting can be done in double rows six feet apart as before, three plants being put in in every four feet of length on each line *i.e.* the distance between plant to plant longitudinally is 16 inches, and with its neighbouring plant in the same double row is 18 inches. It is very important to water the trenches immediately before or after planting the cuttings, if sprouted

cuttings are planted, and it is always better to plant cuttings after sprouting them either by topping or by pitting.

612. *Pickling.*—As sugar-cane is very much subject to the attack of insect and fungus pests, it is important to sow the cuttings or seedlings after pickling, *i. e.* after smearing each lot of cuttings or seedlings with a mixture of insecticides and fungicides. But as these substances even when used in a dilute form are generally injurious to vegetable cells, it is best to dry up the substances with which the cuttings or seedlings are smeared immediately afterwards with such manurial substances as have some effect in keeping out insects also. Thus if half a pound of powdered sulphate of copper is mixed up with 100 lbs. of hot water and if 8 ounces of powdered white arsenic with 1 lb. of lime, are added to the vat containing the sulphate of copper solution, the sugar-cane cuttings can be dipped in this insecticidal and fungicidal mixture, immediately before planting, but the cuttings after being dipped in this liquid mixture, should have a coating of powdered castor or mustard cake (100 lbs.), ashes (2 lbs.), and soot (1 lb.), that the growth of the young plant may be helped by these manurial substances. If sulphate of copper is not available 1 lb. of alum may be used in place of ½ lb. of sulphate of copper for making the fungicidal solution. Half an ounce of asafœtida may be mixed with every 100 lbs. of the fungicidal solution, as the strong smell of asafœtida keeps out most insects. The mixture should be used up the same day it is made. The quantities mentioned will suffice for pickling cuttings required for 1 acre of land.

613. *Rotation.*—It is best to grow sugar-cane after a preparatory crop of Dhaincha (Sesbania aculeata), Sunn-hemp (Crotolaria juncea) or Barbati (Vigna catiang), cut down when in flower, in August. A crop of potatoes may be grown from October to February, and the land immediately afterwards got ready for planting sugar-cane in February. After the sugar-cane is off the land next February, a crop of *arahar*

(Cajanus indicus) or of *Aus* paddy (if the land is not too poor or exhausted by cropping) should be taken. After the *Aus* paddy, a crop of potatoes may be taken again, and then sugar-cane may come in also. After the *arahar*, (which occupies the land for 9 or 10 months), sugar-cane may follow immediately afterwards, if growing of sugar-cane is the main object of the farm. Otherwise, greater prominence is to be given to ordinary agricultural crops, and one of the systems of rotation described in pages 366—368, adopted, according to the nature of the soil. As indigo-planters are proposing to go in largely for sugar cane, it should be noted here that indigo and sugar cane form an excellent rotation. The slack season for indigo, *viz.*, December to April, is the busiest season for sugar-cane. From May to November scarcely anything need be done to sugar-cane. Letting out the water from fields, tying the canes and one hoeing, are all the operations, needed during these seven months when indigo is being sown, cut, steeped and manufactured.

614. *Manuring.*—Sugar-cane responds well to a heavy outlay in manures. The following mixtures are recommended :—

(1) Bone-meal—10 maunds per acre applied before sowing.
Castor-cake—20 maunds per acre applied after sowing, in two doses.

(2) Cowdung—600 maunds per acre ploughed in before trenching.
Bone-meal—10 maunds per acre before sowing.

(3) Bone-meal—10 maunds per acre applied before sowing.
Saltpetre—3 maunds per acre applied in two doses after the plants are a foot high, but before June.

(4) Powdered apatite—6 maunds per acre applied before sowing.
Saltpetre—4 maunds per acre applied in two doses after the plants are a foot high, but before June.

(5) Castor-cake—25 maunds per acre applied in two doses before the two earthings.

(6) Castor-cake—15 maunds
Bone-meal— 5 maunds
Saltpetre— 2½ maunds
} applied together before the two earthings.

(7) Superphosphate of lime—5 mnds. per acre
Sulphate of ammonia— 1½ ,,
Sulphate of potash— 1½ ,,
} a handful being put under each plant when about 1 ft. high.

615. The last mixture is largely used by European and American sugar planters. Some use only Sulphate of Ammonia for sugar-cane grown after a green-crop (such as, cow-pea) is ploughed in. Sulphate of Ammonia containing over 20 per cent. N can be had for Rs. 10 per maund. Sulphate of potash costs about the same. Superphosphate of lime would cost about Rs. 4 per maund.

616. *Subsequent operations.*—When the land has been thoroughly prepared by deep cultivation, harrowing and rolling, and cuttings planted after trenching and watering and when manuring has been done, the intervals between the plants should be given one hoeing with the Hunter hoe after each watering. From March to June four irrigations may be needed. But the need for irrigation depends mainly on the variety of sugar-cane grown, and the time of sowing. If a coarse variety (such as Khari or Kajli) is grown, and if the sowing is done in April (after irrigation), one subsequent irrigation will be found sufficient to bring the plants on. But even in this case two or three hoeings, and one hand weeding will be found helpful during May and June, after which nothing need be done till harvest time. To break up the surface pan it is important to do a hoeing after each irrigation, the first hoeing should be with hand-tools. The superior varieties of canes that have soft skins are particularly benefited by tying. The tying protects the canes from the attack of insect and fungus pests and jackals, and the growth is more uniform and clean. The opposite practice of 'trashing,' or tearing away the leaves as the canes grow, probably accounts

for the ravages of the Trichosphœria fungus in European and American cane plantations. The scars formed by trashing offer excellent resting places for spores of the fungus, while the enveloping of canes from below upwards with the leaves, as practised in this country, probably offers a great protection not only against the spores of the fungi resting on the canes, but also against the insects laying eggs on the canes. It is also said that tying increases the yield of *gur* but this point must be established by repeated comparative experiments. From July to October, the canes should be tied twice, and they should be so supported against one another during the tying that they may not lodge.

617. *Harvesting.*—When there is little moisture in the soil, and when the top leaves have begun to wither, the canes should be considered fit for cutting. The practical farmer would also judge from the taste of the canes whether they are sweet enough to be cut. If too much time is wasted in judging whether canes are quite ready for cutting or not, the excessively hot and dry weather may come on during the progress of the harvest operations, and then the yield of juice, and the quality of the *gur* turned out will be inferior. December to February is the proper season for harvest in canes in Lower Bengal; but if owing to late rains, or late sowing, the plants look quite vigorous and green in December, and if the canes do not taste sweet enough, one must wait a fortnight or perhaps a month before commencing cutting the canes. The canes should be cut with *kodalies* close to the ground, rather two or three inches under ground. If stumps are allowed to be left on the ground, these send out in the case of ratooned canes, poor shoots which yield a poor return next year. Sometimes from these prominent stumps flower-stalks come out, but owing to their want of strength the arrows cannot come out of them, and they become smutted and dried up. This smutting of flower-stalks in the case of the Khari sugar-cane has been observed to do no harm,

as shoots coming afterwards from deep down the earth grow up vigorously and continue to grow side by side with the smutted flower-stalks, apparently unaffected by them. But it is never safe to allow a luxuriant growth of parasitic fungus, as a fungus may sometimes prove very injurious though at other times they do not seem to do any practical harm.

618. *Cost of growing an acre of sugar-cane.*—In the following estimate, the wages have been calculated at the rate of 4 annas, and the most approved system only taken into account.

	Rs.	As.	P.
Harrowing the field after lifting potatoes	0	6	0
Rolling	0	6	0
Trenching with Double-mould-board plough ...	0	12	0
12,000 cuttings at Rs. 2 per 1,000	24	0	0
Cost of getting the cuttings sprouted in a pit ...	1	8	0
Cost of pickling the cuttings	5	0	0
2 maunds of apatite (*i.e.* 10 mnds. per acre once in 5 years)	6	0	0
Castor-cake, 15 maunds	30	0	0
Saltpetre, 2½ maunds	15	0	0
Cost of planting cuttings (24 men)	6	0	0
Cost of filling up blanks, a month afterwards ...	0	8	0
Cost of applying the manure before the two earthings ...	4	0	0
Cost of three irrigations (February, March and April) ...	9	0	0
Cost of one irrigation in November	3	0	0
Cost of one hand-weeding	4	8	0
Cost of one hoeing with Hunter hoe	0	12	0
Cost of two more hoeings (earthings) with Hunter hoe ...	1	8	0
One hoeing with *kodalies* (15 men) after the November irrigation	3	12	0
60 men employed in cutting and stripping the canes (distributed over 12 days)	15	0	0
One man employed for 12 days at the crushing mill ...	3	0	0
One man employed for 12 days for driving bullocks ...	3	0	0
Hire of 2 pairs of bullocks for 12 days	6	0	0
One man clarifying and boiling the juice for 12 days ...	3	0	0

Fuel for the first 2 days	1	0	0
Quick-lime, phosphoric acid, and litmus paper ...	1	0	0
Cost of employing a man for making sugar and assisting in *gur*-making	3	0	0
80 earthen pots	4	0	0
Interest and depreciation	2	0	0
Rent of land	3	0	0
TOTAL Rs.	160	0	0

Outturn.—40 maunds of native white sugar at Rs. 6 ... Rs. 240
5 maunds of clean molasses at Rs. 2 per maund ... Rs. 10

TOTAL Rs. 250

619. *If Chewing Canes* are sold, 20,000 canes sold at 1 pice each, would mean a gross income of about Rs. 300 per acre. In this case the cost of *gur*-making is saved, but for growing superior varieties a little more expenditure on account of irrigation, hoeing and tying the canes, will bring up the total to about Rs. 150 per acre without the cost of *gur*-making. The cost after the first year in the case of ratooned varieties, is less, by about Rs. 30 per acre. In Bihar, where wages can be calculated at 2 as., the cost of growing an acre of sugar-cane may come to only about Rs. 100 or even less.

620. For killing jackals and pigs, a gun should be in constant use in a sugar-cane plantation. Dogs may be also kept for the same purpose, specially as they may prove very useful in the apprehension of thieves.

621. *Crushing of Canes.*—With a two-rollered Behia Mill (Fig. 57) one gets only about 58 per cent. of juice out of

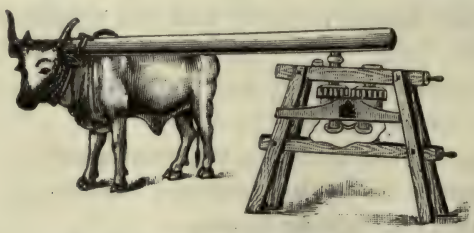


FIG. 57.—THE BEHIA MILL.

canes. With a three-rollered mill one gets about 64 per cent. The former costs Rs. 80 and the latter Rs. 100. A still higher yield (about 72 per cent.) is obtained with the help of a horizontal roller-mill worked by steam-power. The three rollers of this mill are each 6 or 7 ft. long and 30 to 32 inches in diameter, and a large quantity of sugar-cane can be thus put in at once into these rollers, while only 3 or 4 canes only can be fed into the Behia mill, at a time. The roller mill set up at the Begum Serai Indigo Factory in Bihar (which has been supplied by Messrs. Jessop & Co. of Calcutta) and which is worked by a 6 H. P. engine, is capable of crushing 20 tons of sugar-cane per day, while a crop of 20 tons of sugar-cane (which is usually obtained out of an acre) requires 10 to 12 days' crushing with the Behia mill. With the help of a shredder which divides up the canes longitudinally before they are crushed, a higher percentage still than 72 is obtained, and with the help of Faure's Decorticator which divests each cane of its rind before it is crushed, as much as 80 to 84 per cent. of juice is obtained out of canes. Sugar-cane contains naturally 85 to 91 per cent. of its weight of juice, which is the maximum possible yield, but no mechanical pressure can be applied to get the whole of the maximum 91 per cent. out, and the yield obtained by Faure's Decorticator may be looked upon practically as the highest possible yield of juice obtainable. Messrs. Jules Karpeles & Co., Indigo merchants of Calcutta, are the agents for this machine. The percentage of juice that is obtainable from the cane does not altogether depend on the crushing mill. A cane which contains 16 per cent. of fibrous matter, and 18 per cent. of cane-sugar, would yield only 45 to 50 per cent. of juice, while one containing 10 per cent. of fibrous matter and 18 per cent. of cane-sugar, will yield about 70 per cent. with the same crushing appliance. The rind and other fibrous matters, act like sponge in retaining the juice. By getting rid of the rind one gets a higher yield of juice. There may be considerations that may deter-

mine a planter to prefer a hardy fibrous variety to a soft cellular variety such as the Samsara or the Otaheite cane, and in such a case the use of a decorticator or at least a shredder before crushing is advisable. But as the horizontal mill, the shredder, or the decorticator, would cost more money than our cultivators could afford to spend, these improvements are meant for planters and capitalists who may wish to launch out into sugar-planting.

622. Whether steam-power, bullock-power, or buffalo-power is employed for crushing canes, it should be borne in mind that too great a speed or jerky motion of the rollers results in diminished yield. This precaution is specially needed where steam-power is employed for working the mills. A roller of 30-inch diameter should make only about 4 revolutions per minute. Modern appliances for crushing sugar-canes, and for clarifying and boiling the juice, are obtainable of Messrs. Pott, Cassels and Williamson and Messrs. Laidlaw & Co., both of Glasgow, and also of the Sangerhauser Engineering Co. Ld. of Berlin.

623. As the subject of *gur* and sugar-making has been dealt with in the previous chapter, we will conclude this chapter by giving the actual figures as to yield of canes, juice and *gur* for two plots of Khari sugar-cane grown at Sibpur in 1900—1901, one manured with the refuse of Cossipore Sugar Factory (*i.e.* principally bone-charcoal) at the rate of 5 mnds with saltpetre at the rate of 2½ mnds., per acre, added to it, and the other manured with 10 maunds of castor-cake per acre. The crushing of the canes was done in both cases with a two-rollered Behia mill.

	Bone-charcoal plot.	Castor-cake plot.
Yield of canes per acre	... 483 maunds	405 maunds
Yield of juice	... 59 per cent. of the weight of canes	56 per cent. of the weight of canes
Yield of *gur* per acre	... 38 maunds	37 maunds

624. It should be noted here that the crushing of the canes out of the Bone-charcoal plot was done a month too early, and had it been done at the same time with the other, this plot would have shown still better result. The value of phosphatic manures for sugar-cane is so well-recognised, that confirmation of the fact is hardly needed.

CHAPTER LXVII.

INDIGO.

VARIETIES.—The variety of indigo grown in Bengal (*i.e.* Indigofera tinctoria) is not the richest in Indican, and the Madras variety (Ind. anil) is still poorer. The varieties richest in the dye-stuff are Ind. Oligosperma and Ind. Leptostachya of Java and Natal. Seed of Indigofera Oligosperma should be procured and grown for seed under proper conditions of soil, manure and cultivation. A dry climate such as that of the N.-W. P., and soil naturally rich in lime should be chosen for a seed-farm for indigo.

626. *Manure.*—Indigo like all leguminous crops grows best on soils rich in lime. Hence the superior yield of some Bihar districts. Potash and phosphates in the soil are also helpful. The application of manures containing phosphates, lime and potash in a concentrated form is being thought of seriously by indigo planters since the crisis in the trade has been brought about by the increased employment of the Synthetic indigo. Mr. Hancock, the Agricultural Chemist employed by the Bihar planters reports an increase of 63

per cent. in one case and of 140 per cent. in another, by the application of such manures.

627. *The crisis.*- The crisis in the indigo trade has been brought about in various ways :—(1) The quarrel between indigo planters and raiyats, on the one hand and Zemindars on the other. (2) The extension of indigo cultivation in the N.-W. P., Oudh, the Punjab (specially in the canal-irrigated tracts of these provinces) and in Madras, and the consequent competition among European factors which has reduced the price to the lowest level. (3) The passing of the industry into native hands almost everywhere except in Tirhut which has resulted in inferiority of produce. (4) The manufacture of the dye by a synthetic process in Germany. With regard to the unwillingness of cultivators to grow indigo, it should be mentioned that the growing of this crop instead of impoverishing their land actually makes it better fitted for the growing of cereals, and if an amicable arrangement can be come to with cultivators by which they can be made to grow indigo willingly on one-fourth or one-sixth of their land in rotation it would be of mutual advantage to the planter and the cultivator. It should be also remembered that indigo refuse is one of the best fertilizers there is. Many factories burn the refuse for feeding engines, which is a great mistake. Some fast-growing tree such as the Casuarina should be grown for fuel and the indigo-refuse utilized for manure.

628. *Cultivation.*—In alluvial soils and in lands annually renovated with silt, indigo cultivation is very inexpensive. Simple cultivation after the water has gone down followed by broadcast sowing is all that is required. No irrigation is done in such tracts. In Patna, Gaya, Shahabad and parts of Chhotanagpur, indigo is grown by irrigation, as also in the N.-W. P. and the Punjab. In Tirhut, Sarun and Champaran *i.e.* in North Bihar, a very careful system of cultivation is practised, which includes digging the land deep immediately after harvest. The seed is drilled with a seed-drill, next

season, on land well prepared by ploughing and rolling with a wooden roller, and the fields are hoed and irrigated when necessary. High class cultivation is also practised on elevated lands in some parts of Bengal also, *e.g.* in Jessore and Nadia. Pruning or feeding the crops for a day by sheep and goats is also practised in some localities. The best indigo is produced in high lands under a careful system of cultivation. The spring-sown crop yields the best dye, but as cultivators are eager at this time to sow *Aus* paddy which is directly more remunerative, it is not always convenient to get a large tract sown in spring.

629. When *Falguni* sowing is done on high lands (*i.e.* in February or March) the land must be thoroughly prepared by manuring with *nil-siti,* deep ploughing, rolling and ploughing, and rolling again. Sowing is done by a drill after which the land is again rolled. In 3 or 4 days the seed germinates. One or two weedings are then given until the plants are sufficiently high. The *Falguni* indigo is grown where there is facility for canal irrigation. In dry soils sowing goes on in July to September and the crop is cut in September or October. The second year's crop from early sowings and late sown indigo crop are called *Khunti.* October sowing (*chhitáni*) is done on *char* lands after the water has subsided and when the land is quite soft, without any preparation, but later on in October sowing is done in higher land after ploughing and laddering, when there is still sufficient moisture in the soil. October and April are the two usual seasons for sowing indigo. With indigo sown in October is usually grown some oil-seed which yields the raiyat an additional Rs. 6 or Rs. 7 per acre and the October sowing of indigo is, therefore, not so unpopular with the raiyat as the April sowing. 10 to 15 srs. of seed are required per acre. 30 to 40 bundles (a bundle weighing about 300 lbs.) is the produce per acre and the yield of dye about 12 lbs. per acre. In Lower Bengal the average yield is 10 to 12 lbs. per acre

and in Bihar 20 lbs. per acre.* Indigo is ripe for cutting when the flowers are just appearing, *i.e.* about June or July, if sowing is done in February to April. The arrangements for manufacturing being completed, cutting begins. The lowest lying fields are chosen first. The crop is cut with sickles and tied into bundles, and as the crop is bought at so many bundles (say 4 or 5) per rupee, when it is cultivated by raiyats and sold to the factory, a chain of a definite measure is used in each factory. But different factories use chains of different lengths.

630. *Manufacture.*—The bundles of plants are put in fresh in the steeping vat, water is poured upon them and they are pressed by means of bamboo rods and heavy beams of timber. The bundles remain in this condition for one night. There are two sets of vats. The second set is at a lower level to the steeping vats and when steeping has been completed in the first set, the yellowish liquid containing the dye is drawn off from it into the second set. Here twice the number of men employed in pressing the bundles is employed inside the vats in stirring up the liquid with bamboos to oxygenate it. When the liquid has changed from a yellowish colour to indigo colour the stirring is completed. From these stirring vats the liquid is run off along a channel into a trough or well, whence it is pumped up into the first drying house, where it is subjected to boiling. From here

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* With the help of Mr. Rawson's Blower for oxidising the liquid as it comes from the steeping vat 25 to 30 per cent., more of colouring matter has been obtained. With the ordinary appliances Bihar factors obtain about 10 seers of indigo (60 per cent. purity) out of every 100 maunds of green plant, and with the blower 12½ seers are obtained. The indigotin is contained in the leaf, and the weight of leaf on plants may be as much as 60 per cent., or as little as 10 per cent. The leaf of Indigofera tinctoria of Bihar yields about ·55 per cent., of indigotin, which is equivalent to 36 seers of indigo out of 100 maunds of leaf. Taking an average good plant to contain 40 per cent., of leaf, 100 maunds of green plant would yield 14·7 seers of indigo (60

the thickened liquid is discharged on a stout cloth spread on a platform of bamboo laths. The water percolating out is pumped up again and again on the mass of soft dye until the water percolates out, not indigo coloured but of a dark red tint. If it takes too long, alum water or *palas* gum is used, when the indigo is readily deposited. The cloth is then folded over and pressed. The press is tightened every now and again for 5 or 6 hours and afterwards gradually and gently loosened, and the cake, which is about $42 \times 24\frac{1}{2} \times 3\frac{1}{2}$ inches in dimension, exposed. This cake is then marked off into 3 or $3\frac{1}{2}$-inch square blocks and the slab on which it rests removed to another room where the cutting and removal of the cakes from the slab are accomplished, the cakes being removed on the drying or cake house, which is a well-ventilated room, protected from dry and hot winds. The cakes are arranged in bamboo-shelves and turned from side to side that every side may get equally dry. The cakes are removed when quite dry to a sweating room where walls of cakes are made and covered with blankets and dry bran and the doors closed so that little air may find access into the room. In about a fortnight the sweating process is completed when air is let in slowly and the walls of cakes uncovered by degrees, the blankets being removed in 4 or 5 days. The process of sweating improves the brilliancy of the dye and it gives a white skin to the cakes which is highly appreciated by buyers. The whole process of drying from the time the pressing of the fecula or pulp takes place requires about 3 months. The cakes are brushed when ready for packing and packed into cases of well seasoned wood. Improvements in the manufacture of indigo have been lately brought about by Mr. Christopher

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per cent. purity). As $12\frac{1}{2}$ seers are now obtained with the help of the Blower, it may be inferred that it is possible by proper fermentation or otherwise to obtain another 2 per cent.

Rawson, who by a proper method of oxidising has obtained an increased yield of 25 per cent.

631. *Pure Indigo Tests.*—Whether a fabric has been dyed with pure indigo or with some inferior dye can be judged by the following tests. (1) Put 2 or 3 drops of ordinary commercial nitric acid on some portion of the fabric. A yellow spot with a green rim quickly appears if the dye is pure indigo. (2) Make a mixture of 1 part Sulphuric acid, and 9 parts of water and in it boil quickly for 10 minutes a piece of the cloth to be tested, say 1½ inches square. Care must be taken always to pour the acid gently into the water and not the water into the acid. If the cloth has been dyed in pure indigo the solution will remain colourless. (3) Dissolve about 1 oz. of common washing soda in half a pint of water and gently boil in it for 15 minutes a 1½ inches square piece of cloth. If the dye used is pure indigo the liquid will remain colourless.

632. The *artificial indigo* of commerce manufactured in the Badische aniline factory in Germany, is almost pure indigotin, containing no indigo red, no indigo brown and no indigo glue, which is a disadvantage, as these substances have some beneficial effects in dyeing. But artificial indigo is likely to supplant natural indigo in the long run when the defects of the artificial product will be supplied by artificial means. Woollen fabrics dyed with natural indigo may be distinguished from those dyed with Badische indigo by holding the two fabrics over steaming water. The one dyed with vegetable indigo will emit an agreeable odour, while the chemical indigo will give out a tarry smell.

CHAPTER LXVIII.

TOBACCO.

Soil and climate.—A light soil or sandy loam, well drained, containing an average amount of organic matter and rich in mineral matters, is considered to be best suited for tobacco cultivation. Grown on clay soils, the leaf becomes too coarse and inferior in quality, but clay soils usually give heavier yields. Sandy loams, rich in organic matter, produce a better sort of tobacco of the kind fit for making cigars. The principal tobacco-growing districts of Bengal, in their order of importance, are, Rangpur, Cooch Behar, Jalpaiguri, Purnea, Darbhanga, Mymensingh, Nadia, Muzaffarpur, Jessore, Manbhum, Murshidabad, Dinajpur, Chittagong, Dacca, Tippera, Bhagalpur, Pabna, Monghyr, and Cuttack. The Chittagong Hill Tracts produce the best tobacco in Bengal. This is generally used for making cigars by the Burmese. There are three varieties : (1) Khao Doung, (2) Mri Kheoung, and (3) Rigre Kheoung. The excellence of these varieties of tobacco, is said to be due to the speciality of the soil rather than to any peculiar mode of cultivation or of curing. The leaves are cured in the way in vogue in Rangpur and Jalpaiguri. The Chittagong tobacco sells for Rs. 20 or more per maund, while the Rangpur tobacco sells from Rs. 6 to Rs. 12 per maund. The tobacco of other districts enumerated above is sold at Rs. 3 to Rs. 7 per maund. Ignorance of the method of cultivation and of curing causes in many places inferiority in the quality of leaves, but the difference in flavour is no doubt also due to difference in the kind of tobacco grown, to influences of the soils, and to climate.

634. *Chemical Composition.*—Tobacco requires particularly good soil and heavy manuring, as it is richer in nitrogen and in mineral constituents than almost any other crop. The

composition of the leaves varies very much in both nitrogenous and ash constituents according to the richness of the soil or the amount of soluble plant food contained in it. The amount of nitrates in leaves may be as much as 10 per cent. of the dry matter. The ash of Indian tobaccos varies between 16 and 28 per cent., the greater part of which consists of carbonate of lime. The soluble portion of the ash chiefly consists of potash salts, the proportion varying from 5 to 35 per cent.

635. The following table gives the chemical composition of a sample of Virginian tobacco.

Moisture	9·44 %
Nicotin	4·52 „
Ammonia	·53 „
Nitric acid	·83 „
Malic acid	12·05 „
Citric acid	2·81 „
Oxalic acid	3·18 „
Acetic acid	·55 „
Tannic acid	1·80 „
Pectic acid	7·18 „
Pectose bodies and gums	3·61 „
Albuminoids	11·92 „
Total N	2·753 „
Amido N	·616 „
Other insolvent organic matters ...	6·87 „
Cellulose	10·22 „
Oils, fats and chlorophyll	5·90 „
Resins	4·51 „
Starch	·64 „
Total pure ash	13·64 „
i.e, Silica and sand	3·78 „
P_2O_5	·38 „
SO_3	·56 „
Cl	·74 „
Cao	3·94 „

MgO	...	...	...	1·04 %
Fe_2O_3 and Al_2O_3		...	...	·46 ,,
K_2O	...	...	...	2·60 ,,
Na_2O	...	...	...	·13 ,,

636. Potash should occur chiefly as carbonate (or ordinary wood-ash) in the soil, and the richness of a soil for tobacco is chiefly due to the abundant presence of nitrogen, potash and lime, as nitrates, carbonates, sulphates and phosphates. From this it will appear that the most appropriate manures for the tobacco crop are ashes (or crude potassium carbonate), saltpetre, gypsum and lime. But as manuring is expensive, soils naturally rich in nitrogenous and ash constituents, that is, very fertile soils, should be chosen for growing this crop.

637. *Rotation.*—Tobacco is sometimes grown after jute or Indian corn has been harvested, but very often it forms the only crop of the year. Properly manured, it can be grown for three or four years successively on the same ground, and it can be grown nearly all the year round.

638. *Seed-bed.*—The soil of the seed-bed is dug up with spade and manured with rotten cowdung and ashes and then raised about 6 inches. When the ground has been well pulverised and levelled, seed is sown thin, so that each seedling may have about one inch of space around it. After sowing, the seed is lightly covered up with earth. The seed-bed is kept covered with mats until germination takes place. It is necessary also to keep the seedlings protected from rain and heat of the sun. They may require to be watered at intervals of two or three days. Seed is generally sown in the first week of September. In dry laterite soil it is best to do the sowing early, *i. e.*, about the second or third week of August. Half an ounce ($1\frac{1}{6}$ tola) of seed is to be sown to produce plants required for one acre; but loss invariably occurs owing to patches of seedlings growing too thick. It is therefore advisable to grow seedlings from one ounce of seed for one acre

of land. Sometimes ants do considerable damage to seed and seedlings, when ashes sprinkled round and over the seed-bed prove efficacious.

639. *Preparation of land.*—The soil for tobacco planting should be prepared during the months of August and September. Eight to ten ploughings are necessary. Deep cultivation and thorough pulverisation of the soil are most important. The soil should be liberally manured with well-rotted cowdung and ashes. The soil is then to be levelled with a light harrow. It is needless to say that even poor soil can be made to produce a good crop by proper tillage and heavy manuring. Soils destitute of potash, unmanured soils, or soils manured with flesh, bones, calcium chloride, magnesium chloride, or potassium chloride, produce a bad burning tobacco which is unsuitable for making cigars. The use of cowdung also should be avoided in raising tobacco for the manufacture of cigars. Potassium carbonate, salt petre, potassium sulphate, and calcium sulphate (gypsum) are the best manures for tobacco, intended for cigars. They give to the leaves a sweet flavour and burning quality. Gypsum is excellent as a top-dresser, and its use is particularly recommended to Indian cultivators. Crops manured with it suffer less from the effects of drought and require less irrigation. Gypsum is a bye-product in the manufacture of ærated waters and can be obtained very cheap,—at 4 to 8 annas per maund, but it should be used with an equal quantity of lime mixed with it, as the bye-product is liable to be acid. The mineral manures are used generally from $2\frac{1}{2}$ to $4\frac{1}{2}$ maunds per acre. Ordinary household ashes also are an excellent manure for tobacco. They contain a large amount of potash and lime, and are particularly recommended for clay and humus soils.

640. *Transplanting.*—When the seedlings are about 3 inches high in the nursery, that is, after they have shewn three or four leaves, which takes place within six weeks from sowing time, they are fit for transplantation. The transplantation

begins in the beginning of Aswin (the 3rd week of September), and extends as late as the end of Kartick (middle of November). Early planting is preferable, especially for dry climates. The seedlings should be planted in the evening 3 feet apart from one another. Smaller varieties, as Hingli, Motihari, &c., may be conveniently planted 2 feet apart. The transplanted young seedlings are to be carefully watered for the first few days until they strike root. Irrigation may be afterwards necessary at intervals of about 10 to 20 days according to the nature of the soil. In Rangpur and Jalpaiguri a hand-plough is repeatedly dragged by a man alternately along and across the tobacco fields, which serves the purpose of hoeing and stirring the soil. This is done until the flower buds are seen. In places where artificial irrigation is required, regular hoeing is wanted - once after each irrigation, or twice a month.

641. *After-treatment.*—A few days before the plants run to flower, their buds and lower leaves should be nipped off, and they should be so pruned that only eight leaves, and on no account more than ten, may be left to each plant from the top. In Jalpaiguri finely powdered earth is used to stop bleeding or overflowing of sap from the broken parts immediately after pruning. This mode should be followed in other districts. Plants reserved for seeding should not be topped in this way, but left to flower and seed. The plants always bring forth shoots by the side of the stalks of leaves pruned, and care should be taken to prune off the shoots every now and again until the leaves are mature. The longer these buds and shoots are kept, the more injury is done to the leaves required to be gathered.

642. *Harvesting.*—When the leaves feel thick and gummy, and begin to turn yellow with brown spots, they are considered mature and they should be cut off. Tobacco should not be cut overripe. Harvesting of a plot should not be done at once: the mature plants are to be gathered first. The

best time for harvesting is morning as soon as the dew is off the plants. They should lie for some time in the sun, say for two hours, to make them sufficiently wilted, so that they can be handled without breaking. Care should be taken not to let them become too much sun-burnt. It is better to cut whole plants (close to the roots) than gather the leaves singly. Harvesting should be delayed for two or three days if there be heavy rainfall, which washes away the gummy matter of the leaves.

643. *Drying and fermenting.*—Immediately after the plants are conveyed to the house, they should be hung up on strings beneath the roof of a well ventilated house 6 inches apart Cow-sheds are commonly used by the raiyats for this purpose, but this gives a bad flavour to the tobacco. The plants should remain hanging for more than two months, or until they are quite dry. When very hot or strong winds blow, the windows and doors of the house should be closed. In very dry weather, the floor of the shed should be occasionally sprinkled with water, in order to keep the air of the room sufficiently moist. In June, when the rains commence again, the plants are taken down, stripped and handled. Best, medium, and worst qualities should be separated at the time of stripping. 16 to 20 leaves are tied up into one bundle. These are put into large heaps 3 to 4 feet square by 5 to 6 feet high and well pressed down with hands. The leaves are transfered from one place to another at intervals of about a week or so; fresh heaps being made, top leaves going into bottom and bottom leaves coming to the top. This transference also involves examination of the leaves. Care should be taken to prevent excessive heating, 90°F being the maximum limit. At the end of the rains the leaves are considered to be fully cured and quite ready for sale. The heap may be broken up earlier, if so desired.

644. *Methods of curing in vogue in Bengal.*—The modes of curing differ in the different districts; and it would be well to cite here the systems of curing in Rangpur, Jalpaiguri,

Nadia, and Tirhut which are the principal seats of tobacco culture in Bengal :—

Mode of curing in Rangpur and Jalpaiguri.—The methods of curing followed in Rangpur and Jalpaiguri are almost the same. The leaves of mature plants are cut off singly in the morning, and are left in the sun for all day long. In the evening small bundles of four leaves are suspended along the roof of the house—generally a cowshed. After two months, *i. e.*, about the middle of June, they are taken down. Eight small bundles are then tied up into a larger bundle. Leaves are not sorted according to their quality though the tobacco-growers are aware that the topmost leaves are the best. The bundles of leaves are then put into a large heap. The bundles are taken out and dusted and the heaps re-made at intervals of eight or ten days, until the tobacco is wanted for sale. It is best to keep on the heap till about the close of the rainy season. Tobacco thus kept is said to bring higher prices.

645. *Mode of curing in Nadia.*—"When cut, the stems with leaves on them are allowed to remain spread out in the sun for two hours. They are then cut into pieces, each of which contains a pair of leaves and portion of the stem. These pieces are then arranged on the ground in layers of 9 to 10 inches thick, and are allowed to remain in the sun for two days. Rain, of course, at such a time is most destructive. Tobacco in this half-dried state is taken home by cultivators, who string the sections together, and suspend them on rows of strings in the longest apartment of their premises, usually the cowshed. The leaves after being thus suspended for about a month are thoroughly cured. They are then taken down on a damp or foggy day when they are a little soft, and made into bundles of about 1½ maunds weight each, the strips of leaves being cut into lengths of about a yard, and folded over and laid one on another. The above description relates to the Hingli tobacco of Ranaghat ; the

inferior sorts appear to be merely made up into bundles and subjected to the alternate action of sun's rays by day and of the dews at night." *Vide* Collector of Nadia's report, 1874.

646. *Method of curing in Tirhut.*—"Plants are allowed to be on the ground as cut, for a day or two; they are then carried to some grassy spot and laid out to catch the sun during the day, and the dew at night, being turned daily. After this has gone on for eight or ten days, every third or fourth day the plants are stacked together till they get heated, when they are again spread out to cool. If at this time the dew is thought not sufficient to cool the plant, at evening time a little water is scattered over the leaves as they lie; this goes on for 20 days or more. The plants are then brought into cover and stacked; they are changed every third or fourth day, the top going to the bottom, and so on. It is important now to prevent them getting over-heated: if the leaves show a tendency to get crisp, the leaves are covered with plantain leaves or damp grass, over which is put a blanket to make the heap sweet. The leaves are then separated by *khurpi* or *huswa* from the stem. They are then tied five or six together with strips of date leaves and piled together. These piles are again watched carefully till it is evident that the leaves will not heat any more. They are then tied up in bundles of 4 maunds each, wrapped round with a straw, and are then fit for the market; if not immediately sold, they are stowed away in some dry place. If the leaves are not of a good colour, the cultivator may, before opening them for sale, get a little good tobacco, boil it and sprinkle the juice over them after the last process of drying; but this is more a trick of trade than a method of curing, which being really nothing more than a careful alternative of heat and moisture, no extraneous matter being introduced." *Vide* Collector of Tirhut's report, 1874.

647. *Seeding.*—The best plants are set aside for seeding. They are not topped like others, but the side shoots and

suckers are removed from the stems, only the heads or tops of the plants being preserved for seed. The heads are tied to sticks to keep them straight. As soon as the seed is ripe, the heads of plants are cut off and hung in a dry and safe place. After a few days the seed is rubbed out of the pods by hand and stored. The seed should be preserved from damp and insects, and it is therefore usually hung up in the cookroom. The vitality of the seed can be tested by scattering some on a piece of hot iron. If a sharp spattering sound is given out, the seed may be considered to be sound.

648. *Outturn.*—A well grown crop is expected to yield from 20 to 24 maunds of cured leaves per acre, the money value of which may be estimated at Rs. 100 to Rs. 120, Rs. 5 being the average price per maund of country cured tobacco.

649. *Injuries.*—The chief enemy of the tobacco crop is a kind of caterpillar which eats away the leaves at night and takes shelter in the soil by day. This caterpillar or cutworm, causes serious damage to the young plants. It should be carefully looked for and killed when any injury from this source is noticed. Hailstorms often destroy the crop over large areas of the country.

650. *Suggestions for improvement.*—The following paragraphs are taken from the *Englishman* newspaper :—" It would be well worth considering the possibility of growing the famous Yenidge and Dubec tobacco so much in demand for cigarettes and for which such high prices are paid. This is grown extensively in the Bulgarian and other principalities as well as in Turkey proper. All the so called Egyptian cigarettes are made from tobacco grown outside of Egypt, better known as Turkish tobacco. The best cigarettes are made in Egypt and not in Turkey itself, and this is ascribed to the dry equable climate of Egypt preventing the deterioration that ensues when such climatic conditions are not assured. We have in Aden the same conditions, a rainless region and on a small scale cigarette-making has for sometime been carried

on there which with certain conditions assured might rapidly expand, especially if such tobacco could be supplied from India.

651. "Tobacco in Turkey is an Imperial Monopoly and every box of cigarettes exported from Egypt pays a tax. These charges might be saved by making them at Aden which would be a great consideration. In the Nepaul Terai there is a tobacco grown by Tharoo villagers, the leaf of which appears to be identical with what is described as Dubec, a small broad leaf free from heavy midrib and large veinings. This appears to be indigenous to that part of the country, and it might be worth while for those interested to ascertain if it is really identical with the Turkish variety. The enormous consumption of cigarettes can be seen from the statistical returns and that the present supply of the special form of tobacco is much below the demand is evidenced by the largely increasing admixture of other imported tobaccos in what is now sent out of Egypt especially American—in fact, Egyptian dealers in offering their wares quote lower rates according to the degree of such admixture—in fact, it is now most difficult to get cigarettes made of purely Turkish tobacco. Tobacco grown from the best imported Havannah seed shows a tendency to run into coarse leaf with heavy ribbing. I should think the Nepaul plant where climatic conditions are more nearly allied would not be so affected or at least not to the same extent; of course, as mentioned above, it has yet to be proved that it is identical with the Turkish variety and possessing the same qualities."

European method of curing.—"When the leaves of the tobacco plant are mature and ready for harvest, they are gathered and first laid on the ground to wilt, that is, to wither and lose their brittleness. This done, they are collected into bundles and packed, top upwards, into moderate size heaps to sweat. Matting is placed over the heaps and a gradual rise of temperature begins. The increase in temperature

is due to certain processes which are taking place within the leaves, whereby, as the leaves die, their more complex contents become broken down into simpler ones, with an evolution of heat and water. The water thus given off is in vapour form, but it condenses again on the cooler matting covering, and it is the presence of this water which gives rise to the idea of the heaps 'sweating.' Care and attention is needed at this time to prevent over-heating, for did the temperature rise unduly there would be darkening of the leaves and injurious drying. When the "sweating" is completed the leaves are dried, either slowly by simple exposure to currents of air, or rapidly by artificial heat. Mouldiness and consequent rotting must be guarded against, and then, if all the conditions are favourable, in six or eight weeks the leaves will have turned a bright warm brown colour, though tobacco at this stage lacks aroma and flavour. The chief result of this process has been to effect a further alteration in the constituents of the tissues of the leaves. After it is completed, moist air is again brought into play to soften the leaves and render them pliant, and it is not till then that they are ready for the great process of fermentation in which, it is now asserted, the bacteria play so crucial a part.

652. "Fermentation has always been looked upon as a very important stage in the preparation of tobacco; but if bacteriologists are right, even greater stress must be laid upon it, for it is the keystone of the whole and of paramount importance. As a preliminary to it, the brown leaves are sorted and made up into hands, or small bundles, containing, perhaps, from six to ten leaves a piece. All these separate bundles are collected and piled up into great heaps or solid stacks—a stack containing sometimes as much as fifty tons of tobacco. Directly the stacks are completed fermentation begins, encouraged by the warmth and moisture within, and now, too, begins the production of aroma and flavour. And this is the work of the bacteria which inhabit

these heaps, for it is conclusively shown that these stacks are the homes and breeding-places of myriads of bacteria—in fact, a complete flora of fungus life is to be found within them, for side by side with the bacteria are members from many other parts of the great group of fungi of which the microbe life is only a small section. At this time the conditions of life are highly favourable to the welfare of this flora and the growth and development of all its members begin apace. And fermentation is the outward and visible sign of the stirring of growth and increase within and its direct outcome. For as the germs develop, food is a necessity to them and they can only obtain it from their immediate environment, hence they draw nourishment from the leaves comprising the tobacco heap, working meanwhile subtle changes in them, and, at the same time, inducing that little-understood phenomenon, heating. Why tobacco, hay, cotton, and other vegetable matter should 'heat' under similar circumstances is at present very vaguely explained. We know, however, one fact about it : it is due to the agency of fungi (among which we include the bacteria), for it has been clearly proved in the case of cotton-waste, for instance, that if the vegetable matter be sterilised so that there is no possibility of germ inhabitants there is no heating ; introduce germ life, and at once, given the presence of oxygen, we have heating. This is, however, at present a phenomenon which presents almost a clear field for research. But in the case of tobacco, heating is carefully checked before it has gone very far by a continuous turning of the stack inside out and 'sides into middle,' no temperature higher than 90 degrees Fahr. being allowed."

CHAPTER LXIX.

PAN OR BETEL LEAF (PIPER BETLE).

THE *pan* crop is one of the most profitable of all crops, and as the knowledge of the cultivation of this crop is almost confined to the *baruis* and is considered a secret by ordinary cultivators, a few notes on the method adopted by the *baruis* may be of interest.

654. *Varieties.*—The three main varieties are *Deshi*, *Sanchi* and *Mithá*, but there are some special sub-varieties, such as *Nuntia*-Bantul, Ujani (Backergunge), Maghai, Karpurkath, which are specially appreciated by the connoiseur. The finest *pan* is grown at Bantul half way between Ulubaria and Midnapur.

655. *Soil.*—High land above inundation level is necessary, as stagnant water is most injurious to this crop. Black friable clay loam resembling tank earth, containing a large proportion of organic matter is the soil ordinarily chosen, but the best *pans* are grown at Bantul on light loam slightly reddish in colour. The soil should be rather moist though high and some of the best *pan* gardens of Backergunge actually get about 6″ of water at high tides during the rainy season. But when the flood is higher the damage done is very serious.

656. Cultivation in the ordinary sense is not required for *pan*, hence the proverb *Biná cháshe pán*, *i.e.*, no cultivation for *pan*. Being a perennial creeper grown in moist soils with plenty of manure, under shade, and the planting being done in the rainy season, (watering after planting being done when necessary), it naturally requires no irrigation except in dry regions. A garden when once established will go on yielding crop after crop for 10 to 30 years.

657. *Preparation.*—After selecting the site for the *baroj* or garden, shrubs and trees growing on it are uprooted, or burnt down and a trench is dug round it, the earth dug out being spread on the land chosen to raise it a few inches above the surrounding land. At Bantul they believe in spading the soil to a depth of 18 inches, pulverizing the soil very fine, and levelling it, before putting on the roof. The frail roofing and fencing have the object of securing shade, evenness of temperature and security from high winds, which are essential conditions for the successful cultivation of this crop. Rows of rotted bamboo or other substantial posts are planted $4\frac{3}{4}$ cubits remaining above ground. Over these are placed *dhaincha* or jute stalks and sometimes a light thatch of *ulu*-grass is also put above the *dhaincha* or jute stalks. The *baroj* is fenced all round with the same materials. Each row of cuttings is planted between two lines of uprights at intervals of 6″ between the cuttings. The cuttings are taken from plants 2 years or more old. They are cut into lengths of 12 to 18 inches containing 5 or 6 joints each, of which two are buried in the earth, and the portions left above ground are made to recline on the surface. These are then covered with date leaves and watered if necessary every morning and evening until they strike root and put forth buds. The planting time extends from May to November. Planting cuttings in nurseries and then transplanting are also practised. As the vines grow one or two Jute or *dhaincha* sticks are stuck into the ground close to each other the upper ends reaching the roof. The vines are tied to these supports with *ulu* straw or *dhaincha* fibre. When the plants reach the roof they are bent down and when sufficiently long a lump of earth is put on the steam which is thus secured to the ground and the bud end bent upwards and tied to another support. This process is repeated and there are usually three bending downwards in the year. Every time a plant is trained in this way 2 or 3 mature leaves are cut away from

where the bending downwards and upwards takes place. In putting earth along the base of the creepers from the two sides the land gets divided into ridges and furrows the plants growing on ridges while the walks alongside them are in furrows. Dried and pulverized pond mud, dried and powdered cowdung and powdered oil-cake, are used each time earthing is done. Castor-cake is said to be injurious to *pan* plants and mustard-cake alone is used in Bengal. Brick-dust is also used as a manure. During the dry months watering has to be done constantly, but stagnant water in *barojes* should be avoided at all seasons.

658. Gourds and pumpkins are usually planted round *barojes* to give additional shelter and profit. The roofs and fences have to be changed every 3rd year.

659. Fungus and insect pests and snails do great damage in *pan* plantations. Fumigation and handpicking of insects and snails can alone be suggested.

660. When planting is done in *Sravan*, plucking commences in *Kartic*; and when planting is done in *Kartik* plucking commences in *Jyaishtha*. After plucking has once commenced, two pluckings are made every month. 2 to 4 leaves are received each time from each plant and in the rains 4 to 6 leaves. All the leaves from an old stem are cut away after a new bent has taken root. One acre of land yields about 80 lakh *pan* leaves per annum, besides inferior leaves from side shoots which are, as a rule nipped off except those kept for making cuttings. For 5 years the plants are in full bearing after which there is a tendency for the yield to fall off. The leaves after being brought home in baskets are sorted and counted by the female members and arranged in bundles of *puns* or hundreds.

661. *Cost per acre* :—

1st year.—

	Rs.	A.	P.
Purchase of 500 bamboo posts and wooden (Jiwol) posts 7 cubits in length, for the support of roof and for fence	40	0	0
Purchase of cane or cocoanut fibre rope for tying ..	7	0	0
Bamboo slips (long strips)	50	0	0
Dhaincha stalks	25	0	0
Ulu for thatching	15	0	0
Purchase of cuttings	50	0	0
12 maunds of mustard-cake	15	0	0
Baskets	1	0	0
Dhenki for crushing oil-cake	3	0	0
Cost of cutting channels and spreading earth ...	5	0	0
Ploughing and pulverising soil	6	0	0
Coolies for planting, thatching, roofing, and fencing...	36	0	0
Coolies for plucking leaves, earthing and manuring ...	288	0	0
Rent	10	0	0

2nd year.—

Purchase of bamboos, betel nut posts and *dhaincha* stalks	100	0	0
Cane or coir-rope	4	0	0
36 maunds of mustard-cake	45	0	0
Ulu	20	0	0
Wages of the permanent labourers for plucking leaves, earthing and manuring	288	0	0
Rent	10	0	0

3rd year.—

Purchase of 150 bamboo posts, 7 cubits long ...	6	0	0
Slips of bamboo and betel nut trees	50	0	0
Cane or rope	3	0	0
Ulu	3	0	0
36 maunds of mustard-cake	45	0	0
Wages of the permanent labourers	288	0	0
Rent	10	0	0
Total of three years, Rs.	1,422	0	0

Every 5th year the expense is increased as the thorough over-hauling of the *baroj* is required. The total expenditure in 10 years is about Rs. 4,600, and the average per annum about Rs. 460.

662. *Outturn.*—Taking 3,000 leaves per Rupee as the average price of *pan*, the outturn at 80 lakh leaves, per annum, may be estimated at about Rs. 2,500. Allowing half this amount for damages due to insect and fungus pests and accidents, the gross income may be safely put down at Rs. 1,200 or Rs. 1,300 per annum.

CHAPTER LXX.

BETEL-NUT (ARECA CATECHU).

THIS is grown as a regular crop in the district of Backergunge, Noakhali and Tippera. The seedlings and young plants are grown in these districts under a papilionaceous tree called *mandar* (Erythrina indica). It enriches the soil and gives the seedlings and young trees the necessary protection from high winds and scorching rays of the sun. The plantation of *mandar* is made in this way. Branches about 6ft. long are planted in February or in April (not March) in rows 12 to 15ft. apart each way. By 2 or 3 years, on high lands, and 4 to 6 years in low lands, the plantation is ready for betel-nut seedling.

664. The betel-nuts are sown in October or November, the seeds being deposited 4 to 5 inches apart. The seed-nurseries are either close to the homestead in shady places, or if conveniently situated, they are made in the *mandar* groves themselves. The transplanting is usually done after 2 years, sometimes 3 or 4 years. In high lands the transplant-

ing is done in July and in low lands in February or April. In the first transplanting, the betel-nut seedlings are planted equidistant from the *mandar* trees, *i.e.* 12 to 15ft. apart. But another transplanting takes place when the first trees have come into bearing. Before this is done the *mandar* trees are cut down or only a fringe left around the circumference of the grove. The betel-nuts in a fully planted grove are about 6 to 7ft. apart each way. A certain amount of irregular planting goes on every year as vacancies occur, and in many gardens plants big and small can be seen every 2 or 3ft. apart.

665. The regular flowering season is February and the plucking season October and November. The flowers forming in January will ripen fruit in October and those forming in March will fruit in December and January. The fruiting begins in the 6th or 7th year, but in crowded plantations not usually before the 10th year. The trees put out in the plantation, when the first plants are in bearing, do not fruit for 20 years after planting. Old betel-nut lands replanted with betel-nut trees after the usual preparation of planting *mandar* &c. do not begin to bear for 20 years after replanting. A plantation is in full bearing after 30 years. The fruiting life of a tree may be put down at 30 to 60 years and the total life 60 to 100 years. Occasional top dressing with tank earth or other earth and hoeing or clearing of jungle are all the operations necessary after the plantation has been once established. According as the soil is clayey or sandy, an average of 8 or 15 maunds of betel-nuts per *Kani* (5 bighas 4 kotthas) a crop worth about Rs. 100, is obtained per annum without much trouble. The crops of large gardens are sold by auction, and the owners have not even the trouble of plucking the nuts. Plucking has to be done with the help of expert labourers who can jump from one tree to another instead of getting down and climbing again.

666. The magnitudes of the betel-nut industry of Backergunge and Noakhali may be inferred from the fact that from

these two districts 30 to 40 lakhs of Rupees worth of betel-nuts is exported annually to Calcutta.

667. The betel-nut crop is subject to a severe fungoid plague which has been the subject of recent investigation. Nothing definite is as yet known regarding the nature of the disease and its remedy.

CHAPTER LXXI.

CAMPHOR, TEJPA'TA', AND CINNAMON.

CAMPHOR (*Cinnamonum Camphora*).—The healthy manner in which two rows of these trees are growing at the Sibpur Botanical Garden leads one to expect that there may be a future for the camphor-extracting industry in Bengal.

669. The camphor tree is found in China, Japan and some of the adjacent islands, including Formosa and the Loochoo islands. It grows wild on hill sides and well drained valleys where the rainfall is abundant in summer. It is an ever-green tree, which is not able very well to stand frost, belonging to the laurel tribe, to which also belong cinnamon and *tejpátá* trees. It attains a height of 60 ft. and more, and the trunk attains a diameter of 20 to 40 inches. The leaves are broadly lanceolate and acuminate at both base and apex. The tree has been successfully introduced into Madagascar, South America, Egypt, Italy and France. The soil best adapted for growing this tree is sandy or loamy soil which is not inclined to be wet. Manured properly it grows rapidly and attains a height of 30 ft. in ten years. The berries of the tree are eaten by chickens and other fowls, and the wood of the tree affords a valuable timber for ornamental work. Irrigation is needed to keep the seedlings and young trees alive in places where the rainfall during the summer months does not exceed 50 in.

It is easily propagated from seed, also from cuttings. The seeds should be collected in October and November, dried and kept packed up in dry coarse sand until sowing time in May or June. The soil of the seed-bed should be of the usual character, *i. e.*, sandy loam mixed up with about one-third leaf-mould. The seed-bed should be kept covered up with mats in the usual way, and it should not be allowed to get too dry. The soil-temperature should not be over 75° F. at the time of germination, though the external temperature may be as high as 85°F. The conditions favourable for the propagation of camphor trees can be secured in some places of Northern Bengal, in Assam, and in the lower hills generally throughout Northern India. The seedlings will grow at a higher temperature than 85°, but the plants in that case will be lacking in vigour. The seedlings may be grown in pots for one to two years until they are ready for transplanting to fields or hill sides. They are ready for trnsplanting when they have attained a height of 20 to 40 inches. They should be planted 20 ft. apart, and after 5 years another lot of seedlings may be planted in between the rows, so that when the plantation begins to be used for the distillation of camphor after 10 years, one lot of plants may replace an older lot. Trees may be cut down when they are 10, 12, 15 or 20 years old according to their growth and the thickness of the plantation. If space can be allowed for a tree to grow uninterruptedly for 20 years, it is best to use it after this period; but younger trees may be lopped if the growth is thick. The largest proportion of camphor being contained in the older and larger roots and diminishing proportion in the trunk, branches and leaves, it is necessary finally to dig out the entire tree to get the maximum yield of camphor. Even leaves and twigs the distillation of which is neglected in China and Japan yield for every 80 lbs. about 1 lb. of crude camphor.

670. The trees are felled with the axe and the larger roots duly cut. They are then cut into chips, and the fresh chips put

in a conical wooden trough 40 inches deep and 20 inches in diameter at the broader base. The bottom of the trough is perforated and fitted on to an iron pan of water set on a masonry furnace. The trough has a tight fitting but movable cover, which is removed for emptying the trough of chips and putting in a fresh quantity. The trough is surrounded by a layer of earth 6″ thick to keep the temperature inside it as uniform as possible. A tube, usually made of a bamboo extends from the top of the trough to a condenser, which consists of one wooden trough being placed on another, the lower one containing water, and the upper one which is placed in an inverted position as a sort of cover to the lower one usually containing clean rice straw on which the camphor crystallizes. The lower trough is larger than the upper trough, so that when the former is two thirds full of water, the edges of the latter are just below water. A continuous flow of water is kept up from the upper part of the covering trough, the excess running out from a hole at the top part of the side of the lower trough. The camphor oil floats on the water inside the lower trough, and the camphor crystallizes in the rice straw with which the upper trough is filled or floats in the water at the lower trough along with the oil. After the steam has carried away the essential oil with it, it must not come in contact with metal of any kind so the lid of the trough in which the chips are put, the tube leading to the condenser, and the whole of the condenser must be made of wood or other material but never of metal. One tub full of chips requires 12 hours distilling, 20 to 40 lbs. of chips yielding about 1 lb. of crude camphor.

671. The distillation of refined camphor out of the crude Japanese or Chinese camphor takes place in Europe. The European methods of refining are too delicate and complicated for description in a handbook of agriculture.

672. *Tejpátá* (Cinnamonum tamala & C. obtusifolium).—Though a native of the Himalayas, growing at an altitude of

3,000 to 7,000, ft. it grows very well at Sibpur, in shady localities, and the tree is worth growing in moist and well shaded localities, as the use of *tejpátá* as a spice is almost universal in India. A couple of small trees supply all the *tejpátá* needed for one family. The tree should be propagated from seed imported from Sylhet. Seedlings should be grown in seed-beds and in 2 or 3 years, transplanted into fields 10 ft. apart. The leaves can be plucked after the 5th year and the tree goes on yielding for fifty or a hundred years. But as shed leaves are just as aromatic, if not more so than, the green leaves, stripping of green leaves which weakens the trees is not necessary.

673. The true *Cinnamon* tree from the inner bark of the twigs of which the valuable spice is obtained, is the Cinnamomum Zeylanicum. This also grows at Sibpur. The bark of the twigs roots may be scraped and dried and used instead of Ceylon Cinnamon, which, of course, is the richest in aromatic properties. The oil obtained by distillation from Cinnamon leaves and roots of all kinds is almost identical with clove-oil consisting chiefly of Eugenol or Engenic acid. The roots of C. Zeylanicum, also of C. Tamala and C. Obtusifolium, yield some camphor, though the true camphor tree (C. Camphora) is different.

CHAPTER LXXII.

OTHER SPICES.

BLACK-PEPPER or *gol-marich* (Piper nigrum).—Like *pipul* (Piper longum) *gol-marich* grows on a creeper and the habits of the two vines are very much like each other. As *pipul* is grown in many parts of Lower Bengal under the shade of mango, jack and betel-nut trees the growing of *gol-*

marich under similar conditions may be attempted also in low-lying moist districts of Bengal. It grows in Assam, in Mysore, in Malabar, in Burmah, in China and in the Straits Settlements, and the attempt to grow it in the deltaic districts of Bengal is therefore likely to succeed.

675. The propagation of the *gol-marich* and *pipul* vines takes place, as in the case of *pan*, by means of mature branches or suckers. The branches, shoots or suckers are layered *i.e.* bent down into the ground, and when they take root they are severed from the parent vine and planted out in shade, and trailed on to trees. This is done at the beginning of the rainy season. The base of every vine is kept scrupulously clean and well-manured with cowdung cake which acts also as a mulch. Three or four years after planting the vines begin to bear in the cold weather.

676. The berries are brought down from the climbing vines with the help of a ladder. Black-pepper berries are boiled and dried in the sun before they are sent to the market. No preparation is necessary for the long pepper. Mr. Basu, Assistant Director of Agriculture, Assam, estimates the average yield from each vine of round pepper at one seer, valued at 8 annas.

677. *Jira* (Cuminum Cyminum).—Though this spice is in daily use like round pepper, in every household in Bengal, its cultivation is unknown in Bengal. The *Jira* seed of the bazaar does not germinate, but as the plant is grown in the Punjab and Afganistan, attempt may be made to obtain fresh seed and sow it in October in sandy loam soil, *viz.*, such as is ordinarily preferred for growing anise, coriander, *juan* and wild celery (*Ránd*hu*ni*).

678. The wild celery of Bengal needs no such careful tillage or attention like the European Celery. It occupies the field longer than coriander, anise, *Juan* and other garden herbs; that is, while the latter ripen in March, the former is not ready before July. 5 seers to half a maund of seed per

acre is used according to their size. After manuring and cultivation the seed is broad-casted. A hand-weeding, accompanied by thinning follows, after the plants are about 6 inches high. No further notice is taken of the plants until harvest time, when the plants are cut, and when thoroughly dry, the seed is separated out by beating and winnowing. 5 to 15 maunds of seed are obtained per acre, the latter figure applying to coriander and anise which are heavier yielders than *juan* (Carum copticum) and *rándhuni*. *Sulpa* (Fumaria parviflora) is a semi-wild spice which is eaten also as a pot-herb. Like the other garden herbs mentioned, this also is occasionally sown, but it is oftener found coming up spontaneously along with the other spices, the seeds of which usually contain a mixture of *sulpa* seed.

Eláchi.—There are two kinds of *eláchis* or cardamoms in common use as spice,—the *Bara-eláchi* or the greater cardamom (Amomum Subulatum) which is grown in the lower valleys of Bhotan and Sikkim, and the *Chhota-eláchi*, or the lesser cardamom (Elettaria cardamomum), which is grown in moist soils in Western and Southern India. The plants are not unlike ginger plants, and they are perennial. The rhizomes go on growing from year to year, and new plants come up from them, the older the rhizome is, the larger the number of flowering and fruiting stems sent out. The fruit of the lesser cardamom is bleached with soap nut (*rithá*) water and then starched.

679. Propagation may take place either by means of bits of rhizomes, or from seed. Highly manured seed-bed and fields are needed. Protection from sun is needed by the plants, and from sun and rain by the seed and seedlings. The soil of the cardamom field should be moist all the year round but not water-logged. In the valleys of Sikkim and Bhotan beds or fields are made alongside mountain streams, whence water is taken along narrow channels alongside of which the cardamom plants are grown on ridges. This

arrangement secures constant moisture and freedom from water-logging. The shade of betel-nut gardens easy of irrigation might be utilized for growing *eláchis*. The seed may be sown on raised seed-beds in October, and the rhizomes planted in June or September on long and float ridges through the middle of which water can be made to flow down in slow current throughout the dry season, keeping the ridges alongside constantly moist.

CHAPTER LXXIII.

OPIUM (PAPAVER SOMNIFERUM).

SOIL.—Heavy loam or sandy loam near village site, rich in saltpetre, is preferred for this crop. The land should be close to a well, the water of which is known to be impregnated with nitre.

681. *Manure.*—Nitrogenous manures, such as, well-rotted cowdung (150 to 200 maunds per acre) and crude saltpetre (40 srs.) are in general use for this crop. Cowdung cake (20 maunds), ashes (4 maunds), oil-cake (6 maunds), or lime (160 srs.) per acre, are also used for top-dressing.

682. *Rotation.*—It usually follows maize or millet the preparation commencing immediately after maize or millet harvest.

683. *Season.*—In the hills the opium season is from February to June and in the plain from October to March.

684. *Tillage.*—The land should be cultivated as often as possible and brought to a fine tilth before sowing.

685. *Sowing.*—The seed is sown mixed up with dry earth in February or October, as the case may be, usually broadcast, at the rate of 3 lbs. per acre. Camphor-water steep should be used for this (as for all small and delicate

seeds) before sowing, as a preventive against blights and for hastening germination.

686. *Irrigation.*—As soon as seed begins to germinate *i.e.* in about a week after sowing, the field is divided by ridges into rectangular compartments, 8 ft. × 4 ft., the alternate ridges being made broader, as along them water is carried down into the fields. Watering should be done as soon as germination has taken place and resowing where germination has failed. Irrigation is carried on at regular intervals until the crop matures.

687. *Thinning.*—When the plants are 2 or 3 inches high they are thinned out: The thinning out of sickly plants is repeated until healthy plants are left 7 to 8 inches apart.

688. *Weeding.*—This takes place along with thinning.

689. *Flowering.*—75 to 80 days after germination the plants flower. The petals (four in number) are carefully removed when fully expanded and matured, *i. e.*, about the 3rd day after the flower opens. These "flower leaves" are employed in the formation of the outer casing of the opium cakes. In another 8 or 10 days the capsules are sufficiently developed for incision. From January to the middle of March and sometimes till later, extraction of the juice goes on in the plains.

690. *After-treatment.*—After the poppy is off the soil, the land is allowed to lie fallow till the rainy weather crops are sown.

691. *Cost of cultivation per acre* :—

	Rs.	AS.	P.
8 ploughings	6	0	0
Clod-crushing	0	4	0
Seed	0	2	0
Sowing	0	3	0
Making water-beds	0	3	0
Watering 6 times	9	8	0
4 Weedings with thinning	8	0	0

Harvesting (8 coolies at 2 as. a day for 15 days)	15	0	0
Manure	4	0	0
Rent	10	0	0
TOTAL ...	48	4	0

692. *Manufacture.*—The products and bye-products of the poppy are: (1) Opium, or the inspissated sap of the unripe capsules. (2) *Pasewa*, *i.e.* the moisture and soluble ingredients which drain from the opium. (3) Poppy petals, already spoken of. (4) "Trash" or powder prepared for the dried stems and leaves. (5) Poppy heads or capsules. (6) Seed and oil.

693. *Opium.*—The capsules are lanced in the afternoon by the cultivator and the members of his family. Three small lan-cet-shaped pieces of iron are bound together with cotton about $\frac{1}{12}$th of an inch alone protruding, so that no discretion may be left to the operator as to the depth of the wound to be inflicted. The incision is made from the top of the stalk to the summit of the pod. Each capsule is lanced 3 or 4 times and sometimes as many as 8 or 10 times before all the milk is drawn out of it. The drug is collected early in the following morning into small trowel-shaped scoops of thin iron. The opium is transferred to a metal or earthen vessel and it is taken to the cultivator's house for further manipulation. The *Pasewa* drains off and is kept in a separate vessel and the opium is turned over by hand from time to time at intervals of not more than a week. When 25 to 50 lbs. have been collected it is tied up in double bags of sheeting cloth. One healthy plant may yield as much as 75 grains of opium with 5 to 8 scarifications. An acre will yield 200 to 600 Rupees worth of opium to the cultivator.

694. *Pasewa.*—This is the dark coffee-coloured fluid which collects at the bottom of the vessels in which the freshly collected juice of the capsules is placed by the cultivators when brought home. The shallow vessels are filled to such

a degree that the *pasewa* can drain off and be collected and sent in separately for weighment. It consists of the most soluble of the principles of opium dissolved in dew or in moisture. It contains meconic acid, resin, morphia, and narcotine. *Pasewa* is not present in opium collected during strong westerly winds or in the absence of dew.

695. *Leaves.*—The mature petals after being collected are spread in a handful at a time over an earthen plate placed over a slow fire. They are covered with a moist cloth above which is pressed a damp cloth pad until the steam from the cloth, acting upon the resinous matter contained in the petals, cause them to adhere together. The thin cake of petals thus formed is turned over in the earthen plate, and the process of pressing and consolidation repeated on the reverse side. These thin sheets pasted together with lewa or inferior opium and *pasewa*, form the shell of outer casing of the opium exported to China.

696. *Trash.*—The pounded stacks and leaves of the poppy plant when dry at the end of the season are used for packing the cakes.

697. *Seed* and *oil* have been already dealt with under the head of oil-seed crops.

698. In the Government Factories the opium brought in by cultivators is examined according to consistence, colour, texture and aroma, classified, mixed up, moulded into cakes and packed. The constituents of an average cake are :—

Standard opium	...	...	1 sr. 7·50 chtks.
Lewa	...	...	3·75 „
Leaves	...	...	5·43 „
Poppy trash	...	...	0·50 „

699. One man turns out about 70 cakes a day. They then require much attention and constant turning or else they get mildewed. The mildew is removed by rubbing in dry poppy trash. Weak places are also strengthened by extra

leaves. By October the cakes are dry to the touch and fairly solid when they are packed in chests furnished with a double tier of wooden partitions, each tier holding 20 cakes. Each case contains 120 catties (160 lbs.). This is the Chinese opium. What is intended for internal consumption is made in this way:—It is hardened by exposure to direct rays of the sun till it contains only 10% of moisture. It is then moulded into square bricks weighing 1 seer each, which are wrapped in oiled Nepaul paper and packed in boxes furnished with compartments for their reception. This opium has not the powerful aroma of the 'cake' drug meant for China, but it is more concentrated and more easily packed.

CHAPTER LXXIV.

TEA (CAMELIA THEIFERA).

THE natural habitat of the tea plant is the chain of hills which passes through Tippera, Lushai, China, Manipur, Naga, Patkai and Kamti, whence it has spontaneously distributed itself by natural means to the adjacent valleys and plains, east and west, diminishing in size owing to changed climate and soil of the plains. The tea plant was not originally introduced into India from China as is generally supposed, but was carried by man from the Indo-Burman hills into China. The natural habitat of the tea plant being the hills of Assam the suggestion has been made to use Assam hill seed from wild trees for propagating tea bushes in the Darjiling hills. Naturally seed collected from tea plants in plains or seed-gardens does not thrive at high elevations and even seed gathered from wild tea plants growing in plains gives poor result. Plain seed should be used for plains and hill seed for

hills and the indigenous varieties preferred to the cultivated. When seed from the indigenous stocks is used it should be sown in seed beds in shade as naturally the tea plant grows in thick jungles.

701. *Hybridisation.*—The question of hybridisation of tea is supposed to be of such great practical importance, that we will deal with this general subject here. Hybrids are produced by impregnating the ovule of one plant with the pollen of another and it is a very delicate operation, requiring great skill in dexterously cutting out all the immature stamina from a flower (*i. e.* emasculating it) and putting mature pollen grains from another flower with which hybridisation is desired on the stigma of the first flower with a little honey. Two sorts of hybridising must be recognised which may be called respectively hybridising and cross-breeding. (1) True hybrids or mules result from the crossing of two distinct but allied species. In some exceptional cases plants belonging to different genera under the same natural order have been hybridised (*e. g.* Philageria, Elisena, Ismene, etc). On the other hand, nearly allied species, and even different varieties coming under the same species will not always cross. Apple and Pear, Gooseberry and Currant, Blackberry and Raspberry, though closely allied plants have refused to hybridise. The tendency to hybridise or form mules, is rather the exception than the rule. (2) Cross-breeds or *metis* which are called hybrids by gardeners are however quite frequent. They are the result of crossing different varieties under the same species. Indeed this cross-fertilisation takes place so commonly in nature, that it is difficult to grow different varieties of rice, maize, cabbage, turnip, peas, cotton &c., in the same locality without getting them mixed up in the course of 2 or 3 generations.

702. That hybridisation and cross-fertilisation result in a a more vigorous progeny has been very exhaustively demonstrated by Darwin and Gower. In the field of practi-

cal agriculture the brothers Garton two Lancashire farmers, achieved great practical success by crossing different varieties of food yielding plants, and sometimes these with weeds belonging to the same species. The crossing was effected in two stages. First, crosses likely to give the best results were effected, and in the next generation plants showing the desired effect were crossed with each other to fix the type. The principle of a second crossing can be carried on still further to fix the type permanently and avoid reversions to the original types.

703. There is a natural disinclination on the part of plants to hybridise. If the natural pollen and the pollen of another species are placed upon a stigma, the foreign pollen remains inert, and even when the natural pollen is applied a little time subsequent to the foreign pollen, it acquires the supremacy and the embryos prove true and never hybrids. Gardeners are not agreed as to the kind of influence exerted by the male and female parents respectively in determining the character of the mule. All that can be said is, the result from the hybrid seed is a plant differing from both parents, but bearing more or less relation to one or the other and more vigorous than either. Dicœcious plants are less prone to hybridise than those with hermaphrodite flowers. The seeds resulting from hybridisation are in the majority of cases barren. In many cases only a portion of the seeds formed produce fertile plants ; while in some cases the hybrid plants are just as fertile as their parents. It is observed that in fertile hybrid plants, the flowers earliest opened are the most fertile, or sometimes they are the only ones that ripen seed, subsequent flowers often developing fruits the seeds of which are destitute of an embryo. Atavism, or returning to the original type of one of the parents, is a frequent chracteristic of the hybrid. In some hybrids the progeny forming the second and third generations become more fertile than the original hybrid. The resulting progeny from cross-breeding is in-

variably fertile. The yield of seed is larger and finer from cross-fertilised than from self-fertilised flowers.

704. The popular variety of tea known as Assam hybrid is not a true hybrid but a *metis*, the China and the Assam tea plants which were used for cross-fertilising being only different varieties of Camelia theifera. Whether the production of a real hybrid between C. theifera and some other hitherto non-tea producing wild Camelia will produce a stronger race of tea capable of resisting blights better, is a question which has not been taken up yet. That one *jat* of tea bushes is naturally healthier than another, is the common experience of planters, and the question of true hybridisation of the tea plants may be pregnant with important conseqences. But what the planter needs most at the present crisis through which the tea-making industry is passing is not the discovery of a disease-resisting *jat* but the renovation of the soil. It is a mere truism to assert, that the soil on which tea bushes grow is getting more and more unsuitable for the tea plant. The two factors to the problem are :—(1) exhaustion of soil and (2) growth of special parasites both fungoid and animal which are encouraged by the constant presence of a suitable host-plant. The exhaustion of soil can be best met by the application of suitable manures. The manures especially applicable to a crop of which the leaves are used should be particularly rich in potash and nitrogen, also lime. Saltpetre is therefore undoubtedly the best manure for tea plants, also lime. But saltpetre has no insecticidal or fungicidal properties and it is rather costly. Castor-cake if it can be produced locally would be a better manure. Rape-cake, ashes, lime, salt, soot, alum, asafœtida, sulphate of copper, cashew-nut gum, catechu, aloes, and especially the first five which have a manurial value, should be applied as well as saltpetre or castor-cake, for renovating the soil and ridding it of insect and fungus pests. The soil should be kept stirred from time to time during the

dormant period, viz., December to February, after which, application of rape-cake, ashes, lime, asafœtida and salt may follow at the base of each plant and then when any pests are noticed, spraying of the bushes with a mixture of sulphate of copper and lime (1 : 10 with 200 parts of water), then dusting with soot and alum, may be resorted to. This should be followed by top-dressing with salt-petre in March. The flushing of leaf coming after such cultivation and manuring and application of insecticides and fungicides, should be healthy and free from blights of all sorts. Picking of spotted and crumpled up leaves during the dormant period, and burning them, should be also practised.

705. The seed should be kept in moist earth throughout winter and sown in March in seed-beds. When a year old, the seedlings are planted out 5ft. apart. For the first 3 years no plucking is done but the plants are kept pruned in the cold weather 3 to 4ft. high. The first plucking of leaves takes place in the 4th year, after which the plucking goes on regularly 3 times a year as long as the bushes are alive. The first picking is usually done in April.* This makes the best tea of the year. The picking should be done carefully so as not to bruise the leaves, nor injure tender shoots. The third picking goes to make the coarsest tea. About 2,000 plants go to an acre, 250 to 300 lbs. of tea being got out of an acre in three cuttings.

706. *Withering.*—The leaves are exposed to sun and air for the first 2 or 3 hours after picking. But in rainy weather or when the atmosphere is very damp the withering operation is done artificially by passing a current of dry air through the leaves. There is little chemical change in the leaf during the process of withering beyond the loss of a certain proportion of moisture contained in it, and the consequent concentration of the sap ; but if the leaf is bruised or injured, so that the air can gain free access to the sap, a process of oxidation and decomposition sets in almost immediately and causes a loss in the

appearance and quality of the tea. In sound leaf, the commencement of chemical change can be observed at the end of the broken stem, where the constituents of the sap become oxidized, and gradually pass through stages of colour from coppery and dark-brown to black. The amount of moisture which should be allowed to evaporate varies considerably, according to the *jat* of leaf, the time of year, and the weather, but about 33% yields the best results. The object is to make the leaves fit for rolling, as wilted leaves they take and keep a good twist without breaking. The colour during the oxidation process becomes uneven if the withering is allowed to go too far. If artificial heat is employed it should never exceed 100°F. and the heat should be gradually reduced to 85°F. or less when the leaf is nearly ready. The leaves gathered on a wet day should be allowed to get a little over-withered that the weaker sap may be concentrated to the standard proportion and they should be also subjected to a hard and prolonged rolling to break all the cells (charged with more than the usual proportion of moisture) and distribute the juices over all the leaves. Leaves gathered in fine weather require less withering and rolling, the sap being more concentrated. When properly withered the leaves give out a fresh and pleasant aroma, different from the vegetable smell of badly withered leaf. When the atmosphere is saturated with moisture, natural withering even in very hot weather does not take place readily, and artificial arrangements for withering are always desirable as then the conditions as regards hygroscopicity and temperature and time can be regulated to exactness. Temperature higher than 100°F. can be employed for a short time if the leaves are wet, but when the external moisture has disappeared, the temperature should be reduced to 90°F. and retained at 90°F. until the operation is concluded. The leaves in the baskets should never be pressed down but remain loose and they must he brought to the withering room in as fresh a condition as possible.

707. *Rolling &c.*—The object of rolling the leaves is to distribute the juices contained inside the cells over the surface of the leaves by breaking the cells up. The juices thus brought to the surface are easily obtained in the tea infusion. In the process of rolling a great deal of oxygen is also absorbed and the tannin assumes a dark colour and becomes partly insoluble and partly it combines with the albuminoids of the leaf forming an insoluble leather-like substance. Chemical changes during rolling should however be kept down as much as possible and for this reason the rolling machine should be situated in the coolest part of the factory. After rolling and re-rolling, the leaves should be passed through a *revolving sieve* to break up any lumps and immediately afterwards placed in a *drying machine* at 280°F., until the leaves are fairly dry when they can be allowed to cool. When sufficiently cool the heap is removed to the *fermenting room.* If the heap is allowed to remain too long in the drying machine room, it begins to get warm again by fermentation which should be avoided in this room. The fermentation room should be well removed from the engine room and it should have even temperature which is secured by a double roof. There should be a drain in the middle of the fermenting room that the room may be washed and cleaned daily after the day's operation is over. In cool temperature the leaves are kept 6″ or 8″ thick and in hot weather 4″ to 5″ thick and turned every half hour to prevent overheating. About 85°F. is the best temperature, and when the surrounding atmosphere is 90° or 95°F. and rather dry, wet cloth is put on the fermenting leaves to give them some moisture and a cooler surrounding. Properly treated the leaves should be of a bright green colour after the rolling operation, and of a reddish tint half an hour after the rolling operation. This change continues until the younger leaves and stems are a bright coppery colour, while the older and less perfectly rolled leaves are partly reddish and partly green. The leaf is now

re-rolled and fired as described already. A more even colour is obtained by sorting the leaf and placing the different grades in separate heaps to oxidise after the firing operation whereby the older leaf can remain for a longer period without injury to the other. Should the leaf have been over-withered and the sap reduced to too great a degree of concentration, the colour obtained in the oxidation will be dull and dark instead of bright coppery ; this can be partially remedied by moistening the leaf with clean water, either during the first rolling, or when the leaf is put to oxidise, by which means the concentrated sap is better diffused over the leaves.

708. In all cases the leaf and the atmosphere of the oxidising room must be kept damp by sprinkling of cold water, and it is advisable to protect the leaf from draughts by means of wet cloths placed over the heaps. If this is not done the surface of the heaps will assume a blackened appearance, owing to the leaf drying up, and the too rapid oxidation of the tannin and colouring matter. A perfectly moist draught of air would probably not be of any harm, it might hasten the oxidation and change, but it would be necessary to frequently moisten the surface of the heap during the process. The change in the leaf is due, to oxidation and not fermentation proper (caused by living organisms). Experiment has shown that Oxygen gas readily changes the leaf from green to copper in less than half hour and the Microscope has failed to discover any organism or living ferment in connection with this change. Experiments have also shown, that a certain moist condition of the atmosphere and of the leaf itself, is necessary to obtain the desired colour, and also that the best results as regards flavour, pungency &c., are obtained when the temperature of the leaf does not rise spontaneously above 84° to 86°F. A non-living ferment or enzyme such as diastase may be associated with this process. If the leaf is placed on a cement floor, where the heat is partially absorbed as it is developed, it can be thicker than when placed on

boards or cloth raised above the floor; and as a general rule, the cooler the day the thicker the leaf can be placed to obtain the necessary colour in a uniform time.

709. The firing usually takes place in 2 or 3 stages. The temperature employed for the first firing averages about 270° F., but during the second firing, when the leaf is partly dried, although the temperature employed in the machine is not so high as in the first instance, the leaf itself attains within a few degrees the temperature of the machine, since evaporation which makes heat latent, is not great and it is the prolonged high temperature at this stage which causes the loss of oil. The temperature towards the end *i.e.*, when the leaf has once become dry and crisp should be reduced to somewhat below 212° F. say 180° to 200° F. and the draught employed should not be very great, so that the moisture will not be driven away rapidly. If the firing operation is hurried too much, the tea loses in aroma. By 10 minutes firing in a "Victoria" at 260° to 280° F., the oxidized tea loses 50 per cent. of moisture. If the "Sirocco" is afterwards employed, as is usually done, the remainder of the moisture is evaporated too quick, in about 20 minutes (at 220° F.). The second firing should take about 2 hours at a temperature of 180° to 200° F. after 50 per cent. of the moisture has been removed by a Victoria.

710. When the leaf has been fired and oxidized it is ready for packing which is done with lead in well-seasoned wooden boxes.

711. *Cost.*—

Manufacturing charges	...	Rs. 12 per acre	
Establishment including field labour ...	...	...	„ 65 „ „
Manuring ...	...	...	„ 18 „ „
			95 „ „
Profit of Rs. 5 per mnd. on 6 mnds. ...	...	...	30 „ „
		Total cost =	125 „ „

If Rs. 125 are realized per acre, and 6 mnds. obtained as the outturn per acre, tea can be worked with profit. The fixed charge of Rs.65 per acre in European gardens is rather heavy.

712. The principal pests of tea plantations are the Mosquito blight and the Red Spider. Against the former pruning and hoeing and burning have been found useful, also spraying of Kerosine emulsion and against the latter dusting of Sulphur. For a full account of tea-blights students are referred to Indian Museum Notes, Vol. III. No. 4.

713. The *chemical changes* that take place during manufacture of tea are numerous; one of the most important being an increase in the amount of essential oil, to which the flavour of tea is so largely due. A certain amount of volatile fatty acids are also developed from the splitting up of a portion of the albuminoid matter in the leaf, and the sap developes an acid reaction. Some of these on isolation have a sweet nutty flavour and aroma, to which the peculiar smell of properly oxidized leaf is due. If the process of oxidation is prolonged for many hours, the acidity of the sap rapidly increases and the leaf becomes sour and rancid, acids similar to those in rancid butter being developed. These can be got rid of to a certain extent by firing, by exposing the leaf to a high temperature for a lengthened period, but only at the expense of the volatile oil which is dissipated with them. The astringency due to tannin is also greatly reduced during this process of oxidation, the tannin being partly oxidized into an insoluble brown substance known as Phlobaphine and partly combining with some of the albuminoid matter and which gives the leaves a tough, leathery and elastic character easily noticeable on handling. Part of the tannin is also converted into glucose and gallic acid, the former of which tends to give a sweetish flavour to the tea and the latter is less astringent than tannin, and it has not the power of combining with albuminoid matter. The albuminoid matter of the leaf is also partly coagulated by the acidity developed during the oxida-

tion. The greater part of the albuminoid being in the form of an alkali-albumen, called legumin, which has properties very similiar to those of case-in in milk, is precipitated like case-in on the acidification of its solution. This reaction is an undesirable one, as legumin (to which the nutritive value of pulses is due) is a valuable food-material. The following is an analysis of the tea leaf made by Mr. Bamber, the tea-chemist:—

Essential oil	·05 %
Fixed oil	·50 „
Thein	4·10 „
Volatile alkaloid	Trace.
Tannin	18·15 „
Boheic acid	2·34 „
Gallic acid	·83 „
Legumin	24·00 „
Albumin and Globulin	1·00 „
Waxes and Gums	2·88 „
Pectin, Pectoses &c.	12·60 „
Amides	Trace.
Cellulose, fibre &c.	21·20 „
Phlobaphine, resins &c.	7.85 „
Mineral matter	4·60 „
	100

714. Black tea has less tannin than green tea, as the withering process which is allowed to go on much longer in the former case results in saccharine fermentation, the tannic acid being replaced by sugar by the absorption of oxygen, while the green resinous matter is converted into a red or brown colouring matter which gives rise to the red infusion characteristic of black tea. Starch is also converted into sugar during the manufacturing process of tea by the absorption of oxygen.

CHAPTER LXXV.

COFFEE (COFFEA ARABICA).

THIS crop requires a hilly *i.e.*, well drained, rich, ferruginous clay soil *e. g.*, forest land, particularly rich in N. Coffee prefers altitudes varying from 1,000 to 5,000 ft. The temperature best suited for this crop is 60 to 80°F. It grows best in a humid climate, *i. e.* where there is some rain every month, but the total rainfall should not exceed 150 inches per annum. Frost is fatal to coffee plants. Heavy clouds and strong winds are also objectionable. In hot and dry places also coffee has been grown successfully in shade. The Arabian coffee can stand drought better than the Liberian coffee which is preferred for moist localities. Though the cultivation of coffee is at present practically confined to Ceylon and the Lower slopes of the Nilghiries, the experiment of growing coffee elsewhere is worth repeating. In Lohardaga, Chittagong, Darjiling and parts of Burmah and Bombay, the coffee plant has been grown successfully and in some Calcutta gardens also berries have been seen on coffee plants. One experiment conducted in Chittagong gave 9 maunds of berries per acre.

716. *Planting.*—Having selected a suitable site, the jungles should be cleared and burnt, belts of trees giving protection from high winds being left. The roads are then to be laid out and the coffee-house furnished with a good water-supply. Then a spot should be selected for a nursery which should be well drained soil (situated on a slope of a hill) but close to water, that irrigation may be easily done when required. The soil should be rich and retentive of moisture *i.e.*, full of humus matter. After spading and ploughing to a depth of about 20 inches, exterminating all the weeds, manuring

the soil with about 200 maunds of farmyard manure per acre and raising the beds 6 inches above the surrounding soil, seed should be sown 6 to 9 inches apart, and 2 inches deep, and only 1 inch apart from one another along the furrows or lines. The lines should then be covered lightly and mats or palm branches thrown over the seed-beds. Watering should be done early in the morning or after sunset.

717. A bushel of seed will give 10,000 plants, sufficient for covering 10 acres. When the plants have 2 to 4 leaves they should be carefully transplanted, in damp cloudy weather, from the seed-bed to the nursery and placed 9 to 12 inches apart. Then the grounds of the plantation are "lined out" for the reception of the plants. A rope is furnished with bits of scarlet rag at the distance fixed upon between the plants which is usually 7 ft. It is stretched across the plot and stakes are inserted at each rag. The rope is then moved forward a stage at a time, gauged by measuring rods 7 ft. long. Or, a base-line is laid down straight up and down the slope, and a cross-line set off exactly at right angles. On this line stakes are driven into the ground at the distance determined upon for the position of the plants. To each stake a rope is fixed and stretched parallel with the base-line and as straight as possible. Small stakes are provided along these lines. A rope held across them at succeeding stages of equal width as guided by measuring poles 7 ft. long, and the small stakes are put in where the movable rope crosses the fixed ones, each stake indicating the site for a plant. The sowing and transplanting are done in the rainy season. The seedlings are planted out when a year old, and sometimes when 2 years old, in their permanent places in the plantation. 7 feet each way is the usual distance apart at which they are planted, about 1,000 plants going to the acre. Holes are first made where the stakes are planted and then the seedlings removed, a ball of earth being taken up with each seedling, and the

planting done as soon as possible and the earth made quite firm after planting. Weeding is afterwards done as occasion requires. Staking with canes has also to be done for supporting the plants against heavy winds. Filling in blanks when any seedlings die or get sickly has also to be done. A fast growing small tree is usually grown along-side the seedlings to give them shade. Maize is the best crop to grow. Trenching and manuring have also to be organised, the former as a means of draining. Weeds are put in these trenches as a source of manure. The trenches open into catch-drains, whence water runs off into drainage channels. Manuring with lime, oil-cake, cowdung &c., is also done, as coffee is an exhausting crop. Forking or spading once a year to a depth of 12 to 18 inches is also essential, in the dry season.

718. After another 12 or 18 months, *i.e.*, when the plants are, 3 to 5 ft. in height, topping is done, *i. e.*, nipping off the central bud, to check further growth in height. Topped in this way, the berries are more easily gathered and the yield is also heavier. Pruning is also done in such a manner that the plants may remain 5 ft. high and develop horizontally primary branches at intervals of about 6 inches throughout the height of the stem; and to form along these boughs a constant supply of secondary fruit-bearing twigs. All ascending and cross-wise branches or twigs are at once removed, so as to force the plant into the type of horizontal spreading branches which has the advantage of exposing to sun and light a large surface from which the crop can with ease be removed. All secondary fruiting twigs are pruned off after each crop is removed. Pruning should be finished each time before the next season's flower buds begin to form. The lateral or primary boughs should not be allowed to grow more than 2½ feet, otherwise they will droop and exclude the light from those below. All broken, diseased and dead branches should be cut off.

719. The blossoms appear in March of the 2nd or the 3rd

year and they go on appearing every year after. About October begins collection of the crop and preparation of berries. The collection of ripe fruits goes on from October to January. The bright blood-red fruits (*i. e.* ripe fruits) are collected, but deep red or cherry coloured fruits which are not quite mature should be also collected at the same time to save labour.

720. *Manufacture.*—The manufacture of the 'berry' from the 'cherry,' as the ripe fruit is called, is accomplished in the following stages: (1) Pulping, (2) Fermenting, (3) Drying, (4) Peeling, milling or hulling, and (5) Winnowing and sizing.

721. (1) *Pulping.*—The pulp surrounding the beans is removed by a machine, called the Disc-pulper or Cylinder-pulper, when the cherries are still fresh. The Disc-pulper consists of rotating discs the surfaces of which are covered with sheet copper roughened by having projections punched forward. It pulps 20 to 25 bushels of cherries per hour worked by 3 labourers. A double pulper of this type has two such discs and is furnished with a feeding roller and it pulps 40 bushels per hour worked by 4 to 6, coolies, or double this amount, worked by steam. The discs work against smooth iron beds so adjusted that the complete cherry cannot pass between them without getting torn upwards against the beds, and the projections on the discs tear off the pulp, allowing the beans to drop into one receiver and the fragmentary pulp to be carried into another. The Cylinder-pulper, in construction, is not unlike the cotton-gin which drags the lint forward and lets the seeds drop behind. A stream of water flows into the pulper all the time it is working. By means of sieves the cleaned beans are separated from partially pulped cherries, the latter being made to pass once more through the pulper. The stream of water with the stones is carried down from the loft by a tube which dips to the bottom of a basin known as the *hopper*.

722. *Fermenting.*—The stones are then fermented to remove from them the saccharine matter adhering to them which renders it difficult to dry the beans. The stones are carried into tanks which are placed higher than the drying platforms on which the fermented beans are finally spread out. There are usually 4 fermenting tanks, two in which fermentation actually takes place and two in which the beans are afterwards washed. One of each is used for the produce of one day's pulping. All the stones pulped in one day are allowed to remain in the receiving cistern until fermentation has set in, *i. e.* for 12 to 18 hours, according to the temperature. The stones are then run into the washing cistern and the receiving cistern made available for another day's produce.

723. *Drying.*—The washed beans are then carried to the drying floors or platforms where they are exposed to the influences of the sun and atmosphere. The floor is asphalted or simply made of concrete, or the ground is hardened and covered with a coir matting. The last method has the advantage of admitting of the surplus matting being thrown over the beans in the event of an occasional shower, but shed-accommodation, where the beans may be rapidly removed when rain comes on, is essential. During drying, the beans have to be constantly raked or stirred with coolies' feet. Too rapid drying, cracking the beans, and disproportioned drying through careless raking, are to be avoided.

724. *Peeling or miling.*—The outer skin or 'parchment' of the beans is now removed. This is usually done by machinery in Europe instead of in the plantation. The beans are dried in the sun or artificially heated before they are put into peeling machines.

725. *Winnowing and Sizing.*—The peeled coffee as it comes from the mill is subjected to fanning which drives off the parchment and skin, leaving the clean coffee behind. Then the coffee seeds are separated by mechanical means into different sizes that roasting afterwards may be uniform.

726. *Packing.*—The beans are put in cases the timber of which will not spoil the aroma of the coffee.

Prices.—Indian and Jamaica Coffee are preferred to all others in Europe. 50 to 90 shillings per cwt. is the price of coffee in London.

727. Coffee like tea and poppy or any other crop which is grown constantly in the same locality, is subject to many diseases caused by fungi and insects. Exhaustion of soil and heavy manuring are also talked of in connection with coffee cultivation, which is failing in some localities, especially in Ceylon.

728. In a well cultivated estate an expenditure of Rs. 80 per acre is incurred on superintendence and field-labour, inclusive of peeling and freight and an additional Rs. 50 per acre on manures and their application. In some coffee estates a total expenditure of only Rs. 80 per acre is incurred, but the result obtained is proportionately poorer. As half the area is manured annually, the total annual expenditure comes to about Rs. 110 per acre in a well kept garden, and the annual average outturn coming to 2½ to 3 cwts., the crop sold at 60*s.* per cwt. leaves a small margin of profit, while at 40*s.* per cwt., coffee growing does not pay at all. But in an estate where 50 rupees per acre is spent on manuring every alternate year the average comes to 4 cwts. per acre. Growing of leguminous crops and application of bones are the manurial treatment recommended.

729. The Engelberg Huller Company of New York supply all the machinery required for the manufacture of coffee. Their Coffee Huller and Separator No. 5, suitable for small plantations, separates 1,500 to 2,000 lbs. of cleaned coffee in 10 hours, separating the parchment from the coffee. The price of the machine is 200 dollars. A screen used for separating dirt, sticks &c., before the berries are put in the pulper is sold for 90 dollars. A Hand-power pulper is sold for 100 dollars. The Coffee washer is made in two sizes,

the smaller size being priced 150 dollars. Coffee graders are sold for 225 to 275 dollars each, according to size. A Coffee polisher is also made of two sizes, the smaller size being priced 250 dollars. The only advantage of using this machine is, all foreign material, dust &c., mixed with the coffee is rejected by an exhaust-fan, keeping the coffee clean and cool and permitting a more brilliant polish. Coffee Hullers (Fig. 58) are not unlike Rice Hullers in general appearance and in their principle of construction.

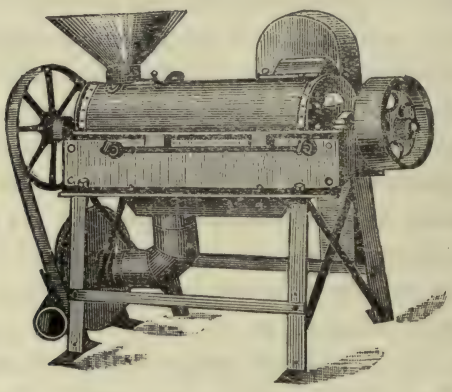


FIG. 58.—THE COFFEE HULLER.

CHAPTER LXXVI.

VANILLA (VANILLA PLANIFOLIA).

VANILLA cultivation has been undertaken by a few European planters of Mysore &c., Vanilla is an essence or flavouring substance obtained from the fruits of a climbing

orchid found growing wild in the hot, humid forests of Central and South America, and a considerable portion of the vanilla of commerce is gathered from wild plants found growing in the forests of Mexico.

731. *Soil and Climate.*—A rich loamy vegetable soil, is the best for the vanilla. An undrained, water-logged soil causes the roots to rot, and it is therefore quite unsuited to the cultivation of the orchid. The climate should be hot, and moist and sheltered situations are indispensable, but the plants must not be too much shaded, or the fruits will not ripen.

732. *Propagation.*—Cuttings 4 or 5 feet long are planted at the foot of trees or other supports used for the vine to grow on and in showery weather they soon take root.

733. *Cultivation.*—The fertilisation of the flowers has to be done artificially and it is necessary for the plants to be trained so as to bring the flowers within reach of the hand. The distances at which the supports on which the vines are to climb are planted, should not be more than 6 feet. The holes should be filled in with rich loam mixed with sand and decayed leaves; and if the plantation be in the vicinity of the forest, the rich humus found on the surface of the ground is sufficient for filling up the holes. The soil must be heaped up so as to prevent water-logging at the base of the cutting. The three lower leaves of the cuttings are removed, and that portion of the stem planted 3 or 4 inches below the surface. The remainder of the stem is then tied to the post or tree by a flat band of plantain fibre, or by a cocoanut leaflet. Round cord must not be used, as it is liable to cut into and injure the green, succulent stem of the vanilla. The ground over the buried part of the cutting is then mulched with leaves or light brush-wood; and if dry weather comes on, frequent waterings will be necessary, until the cutting has taken root. The ground must be kept free from weeds, and, unless it be lightly shaded by growing trees, it will be advisable in dry weather to keep the roots constantly mulched.

734. When the vines have reached the tops of the trees or other supports, bamboos may be fixed horizontally from tree to tree or from post to post, and the vines trained along them. The trees must be kept down low, so that the vines do not get out of reach, and the branches must be judiciously lopped, in order to prevent too much shade. No animal or artificial manures should be used, but rotten leaves and vegetable soil may be applied to the roots after each crop is gathered.

735. *Fertilisation of the flowers.*—The plants will commence to flower in the second year after planting, and full crops may be expected in the fourth year. In the Sibpur Botanical Garden the vanilla creepers are in flower in March and April, and artificial fertilisation is regularly practised, though in the wild state in America fertilisation no doubt takes place through the agency of insects or small birds. The parts of the flower are so arranged that self-pollination is impossible, and therefore it must be effected by some foreign agency. If the flower of the vanilla orchid be examined carefully, the outer floral envelope consisting of 3 sepals, and the inner one consisting of 3 petals, may be made out. The lowest of the petals is very different from the others; it is called the lobellum or lip, and it envelopes the column or continuation of the axis of the plant on which are set the curious anther and stigma. This continuation is called the column. At the top of the column is a hood which covers up the anther and pollen masses and below this is the viscid stigmatic surface, protected and hidden by a projecting lip some times called the lamellune. Thus we see that the pollen is shut in by the hood and the stigma is shut in by the lamellune, so that two obstacles prevent self-pollination. The object of artificial fertilisation is to remove these obstacles, and to permit the pollen masses to approach the stigma. This is easily effected—firstly, by detaching the hood, which is accomplished easily by touching it lightly with a piece of

sharpened wood ; secondly, by slipping the lamellune under the anther ; and thirdly, by ensuring contact of the pollen and stigma by gentle pressure between the fore-finger and thumb. The operation is performed in a few seconds after a little practice, and it may be facilitated by holding the column between the thumb and middle finger of the left hand, whilst it is supported at the back by the fore-finger ; the right hand is then free to use the fertilising instrument, which should be rather blunt and flattened at the end. A tooth broken from an old comb and fixed into a piece of thin bamboo a few inches in length may be used.

736. If the fertilising operation proves successful, the flower will gradually wither, whilst the pod will grow rapidly. If unsuccessful, the flower will fall off before the second day, and the ovary will remain undeveloped, turn yellow, shrivel up, and drop off the stalk. The flowers come out in March in clusters of from 10 to 20, but not more than half a dozen of the cluster should be fertilised, and in this way fine large pods will be secured. Fertilisation should commence at 9 or 10 o'clock in the morning, for if it be done too late pollination may be incomplete, or fail altogether. The fruit goes on growing for a month but it will take at least five months longer to ripen sufficiently for harvesting.

737. *Harvesting.*—The pods are to be gathered when they begin to turn yellow at their ends, or when they produce a crackling sensation on being pressed lightly between the fingers. Each pod should be gathered separately by being bent to one side, when it will come off the stem. It is very important to gather the pods at the right time, for, if they be too ripe, they will split open in curing, and if too green, they are dried with difficulty, and they will have little or no perfume.

738. *Curing.*—After the beans are gathered, they are plunged for half a minute in hot, almost boiling, water. They are then put on mats to drain dry, and afterwards

they are spread out on blankets and exposed to the sun. Every evening they are rolled up in the blankets and shut, up in light boxes to ferment. The sunning process is continued for a week, or until the pods become brown and pliable, when they are squeezed between the fingers to straighten them, and so cause the seeds and oily substance inside to be evenly distributed. Should any of the pods split, they should be closed up and bound round tightly with silk thread or narrow tape. As they dry and shrivel, the thread should be unwound, and the pods tied up again. When the pods are brown, the drying process should be finished in shade, which may take many weeks.

739. *Packing.*--The dried beans are to be sorted according to their length, the long, then, ones being the most valuable. Beans of the same length are to be tied in bundles of 25 or 50, the ligatures usually being applied close to each end of the bundle. The latter are then, packed in closely fitting tin boxes, which are enclosed in rough wooden cases.

740. The Vanilla plants flower very irregularly, and, in consequence, all the pods are not in fit condition, to be gathered at one time, and care is required at the first gatherings not to touch pods which are unripe; if gathered too early the pods or beans will mostly shrivel during the process of drying, and lean shrivelled beans do not realise so good a price in the markets. At the same time, the pods must not be left on the plants after they have ripened, or the valves will open, sometimes nearly an inch, and split beans are of inferior value. 7 to 33 shillings per pound are obtained in the London market according to the size and quality of the beans.

CHAPTER LXXVII.

PAPAYA (CARICA PAPAYA).

AS a heavy yielding fruit and vegetable crop the papaya has hardly its equal and it deserves to be cultivated as a regular crop. The fruit grows plentifully during the monsoon, but it goes on yielding all the year round.

742. The seeds should be dried in the sun and after being kept a week, sown in a box or under cover in rich but light soil. The soil should consist of sand and two-year-old manure. When the plants are a few inches high they should be transplanted to a nursery, and when 2 or 3 ft. high they should be planted out in fields, in holes in which plenty of manure and a few pieces of bones should be put. The trees should be planted in the open and not in shade. The planting should be done 10 ft. apart. When 6 ft. high the central bud should be nipped off and growth of side branches encouraged. The size and quantity of fruits are both enhanced by this operation. Male trees often contain hermaphrodite flowers which go to form fruits. From large sized fruits from male trees (which are best known by their pendulous flowering branches) seed should be taken, as then the tendency will be for both male and female trees to yield fruits.

743. Apart from the great value of the papaya as a drought-resisting crop yielding a highly nourishing vegetable (when the fruits are green) and ripe fruit, the crop is of great value as the source of Papain or Papayotin. The filtered juice of the papya gives some of the reactions of pepsin, but it is different from pepsin, as it acts more energetically in neutral or alkaline substances than in the presence of acids. It curdles milk like pepsin. Pure Papain acts on milk in

5 minutes at a temperature of 60° to 65°F. It dissolves 28 times its weight of coagulated albumin. It also to some extent digests fibrin (the principal albuminoid of meat), some say 200 times its weight—as well as white of eggs. No action, however, takes place when there is much acid. It is for this reason papaya acts so readily in softening fresh meat, if the milk of the fruit is added to the meat a few minutes before cooking. It is not such a ready alimentary digestive in the presence of gastric juice which is highly acid. Papain is present more or less in all parts of the plant, but chiefly in young fruits.

744. In preparing Papain, the juice should be obtained from unripe fruit. Moisture spoils the ferment and great heat destroys its activity. The juice should therefore be dried as soon as possible at a low temperature. The fresh but dried juice should be mixed with twice its volume of rectified spirit; and the mixture allowed to stand for a few hours. The insoluble matter should then be filtered off. The residue should be dried in the ordinary atmospheric temperature, powdered and kept in well stoppered bottles.

745. In the presence of alkali, Papain is not only a valuable aid to digestion but it is also a solvent of the gum of tusser and other cocoons which are reeled with difficulty. The use of Papain as an aid to the reeling of tusser cocoons is recommended for trial.

CHAPTER LXXVIII.

CASSAVA AS FAMINE FOOD.

DURING the late famine persons who went about in rural places could not have failed to notice, how certain crops fared better than others, how certain crops did not suffer at all from the drought and how poor people

took to living very largely on foods which they had formerly looked upon as mere accessories to their dietary. It was noticed, for instance, that where rice, wheat and barley had failed completely, *arahar*, *kalai*, gram, maize and some of the common millets did fairly well, and yams, sweet potatoes, vegetables such as *palvals*, *sajna* and *dumbur* and mash-melons and sweet melons did remarkably well. During this last famine these articles of food were largely used as a substitute for rice. Throughout June, 1897, many day-labourers ate only mash-melons in day time and a little rice at night. A pice worth of melons or *palvals* gave them a full day's meal at a time when two annas worth of rice was required to appease a man's hunger. It is singular that the prices of such articles as milk, fish &c., did not increase and that food far more nourishing than rice,consisting of *palval, kalai, dumbur,* fish and sour milk was to be had at a smaller cost than rice. The famine indeed had the effect of educating people how not to depend on rice alone for sustenance and teaching agriculturists the value of having several strings to their bow, *i. e.*, of growing not rice alone but also maize, millets, *bhadoi kalai*, *arahar*, *ol*, and other crops ordinarily less paying than rice but which do not require the same amount of water for their successful growth and which do not fail when there is a monsoon of short duration.

747. The food stuffs mentioned above, labour under one or other of the four disadvantages: First, they either yield too little produce, or secondly they are too indigestible, or thirdly, they are too coarse or insipid, or, fourthly they do not keep long. The Cassava (called *Simulalu* in Eastern Bengal and *Sarkar-kanda* in Midnapur), stands drought at least as as well as any of those crops, it grows equally well in open or in shade, it yields a nourishing and palatable food, which can be utilized either in the fresh state, or by extracting out of it a flour which keeps much better than wheat-flour, it yields a much larger quantity of dry food per acre than probably

any other crop, and it can be grown with little trouble in the plains of Bengal.

748. The roots of the Cassava are sold boiled in the streets of Madras, and they taste very nice. In Darjiling, Bancoorah, Midnapore and in Eastern Bengal and Assam it is eaten cooked into curries. Fresh roots do not keep long: in the case of potatoes they rot away, and in the case of cassava roots, they become like bits of wood from which it is not easy extracting the farina. Cassava flour is easily manufactured from the fresh roots, and as such, the produce of this crop keeps long, and it can be utilized for food agreeable to Indian taste.

749. One great advantage of growing the Cassava plant as a protection against famine lies in the fact that the roots need not be dug up annually. If a cultivator has a hedge of Cassava all round his fields he can lift the roots only when his ordinary crops fail. In the interval he need not take any notice of them. Properly grown after a few months the tuft of leaves of each tree gets beyond the reach of cattle. The roots go on increasing in number and in size, and they need not be utilized until a year of partial or total failure of the ordinary crops comes round. It should be mentioned however, that Cassava is not a suitable hedge plant as cattle are very fond of its leaves.

750. The most economical way of utilizing the roots, is to lift them once in 10 to 12 months and to treat them as an annual crop. The deposition of starch falls off after the first year, that is, it does not go on quite so rapidly in old trees as in one-year-old plants. In introducing the crop among cultivators, however, it is best to tell them to grow it along hedges and odd corners of their homesteads, that there may be no interference with their ordinary agricultural pursuits. In dealing with cultivators it is ofen necessary "by indirection to find direction out," to introduce improvements tentatively and slowly. Poverty makes them suspicious, and

if you were to tell them to set apart any considerable portion of their land which they now use for growing rice, or *kalai*, or jute, for the Cassava plants, they will jump to the conclusion that you have some ulterior motive of your own to serve and you are merely using them as a cat's paw.

751. It should be noted that there are two varieties of Cassava, both used in America for extracting tapioca, though one of them, *viz.*, the Manihot Utilissima, is poisonous. The Manihot Aipi or the sweet Cassava, the roots of which can be eaten raw, is the safest variety to grow. There is a considerable proportion of prussic acid in the bit- ter Cassava, which, however, is dissipated by the action of heat in the process of manufacture of tapioca.

752. The sweet Cassava, variously called *Himelalu* (or Simul-alu), from the resemblance of the leaves of this plant to those of the tree cotton or *Simul*, *gach alu* (or tree potatoes), *ruti-alu* (or bread potatoes) and *Sarkar-kanda* (or sugar-root) was first introduced into Western India, from America probably by the Portuguese. In the Bombay Presidency it is not utilized for food, but in Southern India, in Cuttack, in Burmah and in Assam and in some parts of Bengal also, the roots are eaten either raw or boiled, or curried. The art of making flour out of the roots is not practised any where in India. As a garden plant or an ornamental hedge-plant, Cassava is met with in many parts of India. One can taste the root and find out for oneself whether a particular plant is sweet Cassava or bitter Cassava, before taking cuttings out of it.

753. We will now describe the process adopted at the Sibpur Farm in manufacture of tapioca meal, and Cassava flour, out of the roots dug out of nine Cassava plants, all one year old. The leaves of these nine plants and the root barks were given to cattle, who ate them with relish, and all stems and branches were used for making cuttings. So no portion of the plants was wasted. If you do not want to use all the stems for making cuttings you can

at least use them for fuel. A plantation of Cassava would thus give food, fodder, and fuel. Now to the manufacture of the flour. The following method was adoped :—The crude roots were dug out and cleaned superficially and of adhering earth and root-scabs by washing them, and they were then left soaked in water for six to eight hours. This soaking in water rendered decortication quite easy. The roots were taken out one by one from the trough in which they were soaking, a slit made with a knife in the bark, which was then easily peeled out. The core of the root was then made into slices and put in a trough of filtered water. The slices were left soaking in the filtered water for an hour and then pulped with a *dhenki*. The pulp was tied in a cloth and put under heavy weight. A cheese-press was used for this purpose. The object of putting the cut slices in water and the pulp under weight is to get the little trace of prussic acid which occurs even in sweet Cassava, out. The slight trace of acrid substance in the sweet Cassava produces no disagreeable effect even when the roots are eaten raw, but its presence can be slightly tasted, and it is much pleasanter to get this slightly disagreeable taste out of the pulp before flour is made out of it.

754. If it desired to make tapioca meal or tapioca as well as Cassava flour out of the pulp, the pulp is put in a cloth and kept stirred half-dipped in a trough or *gamla* of filtered water. This helps the farina to go downward, settle at the bottom of the trough and also more of the acrid substance to be washed out of the pulp. After stirring the pulp in the cloth for an hour in one trough, it is to be stirred for a few minutes in another trough of filtered water and then the excess water squeezed out, and the pulp tied in the cloth is to be passed once more through the press and then spread out thin, exposed to the sun to allow of its getting dry the same day, if possible. If the crude roots are left in the wash tank overnight, say, from 9 P.M. to 5 A.M. and the decorticating and sli-

cing got over by 8 A. M., the sliced roots left in the soaking tub from 8 to 9 A. M., the pulping got over by 10 A. M., and extraction of the farina by midday, all the afternoon will be available for the pressed pulp to get dry. As the manufacturing should be done at the driest season of the year, *viz.* February to April, there should be no difficulty in getting the pulp thorougly dry and ready for grinding by 5 or 6 P. M. At Sibpur, the grinding was done with an ordinary hand stone-mill and the flour was afterwards separated out with an ordinary hand-sieve. The resulting flour was beautifully white and sweet and it kept sweet for more than a year.

755. The farina or starch which settles down at the bottom of the troughs is collected quite easily by pouring out the water from them. The starch occurring in a compact and heavy mass does not flow out. The starch is allowed to settle again, and the water then poured off with the water. A fresh quantity of filtered water being poured out, the starch is exposed to the sun and collected in a dry state. The moist starch of some troughs may be converted into tapioca-meal or Brazilian arrow-root by drying in the sun, as above, and of others into tapioca. The tapioca-meal which is sold as "Brazilian arrow-root" in London, can be used as a substitute for ordinary arrow-root or cornflour.

756. The moist starch is simply exposed to the sun and made into tapioca-meal. But to convert it into tapioca it is put into a brass or aluminium pan in the moist state and heated on a slow fire with constant stirring with a brass *khunti*. As soon as the meal assumes the granular appearance of tapioca it should be taken down from the fire and left to dry more perfectly in the sun.

757. These were the actual quantities obtained at Sibpur out of nine Cassava plants :—220 lbs. of crude roots, 149½ lbs. of pressed but moist pulp, 33¾ lbs. of Cassava flour, 5½ lbs. of tapioca-meal, and 6¾ lbs. of tapioca, or a total quantity 45½ lbs.

of dry food, also 107 lbs. of leaves which were eaten with avidity by cattle, and 937 cuttings.

758. Planted 5 feet apart an acre would hold about 1,700 plants. If the Sibpur experience is repeated on a large scale, we ought to get over 450 maunds of crude roots and over 210 maunds of green fodder per acre. When it is recollected how difficult it is to get green fodder in some parts of India during the driest months, the produce of 240 maunds of green fodder for cattle, which is a mere bye-product, seems sufficiently inviting. If the value of the fodder alone is estimated at two annas a maund, we have an outturn of Rs. 30 per acre. Then there is another bye-product in the shape of cuttings or fuel, which would be 175 to 200 maunds per acre, which represents another Rs. 50.

759. The price of tapioca is six annas a seer in Calcutta. Putting the whole produce of Cassava flour, tapioca-meal, and tapioca at the lowest value of, say, two annas a seer, *i, e.*, Rs. 5 a maund, we can expect a gross produce of Rs. 500 per acre from the flour and meal.

760. Working on a large scale, the produce of flour will come, perhaps, to 50 maunds per acre instead of 100 maunds. The account of produce of Cassava flour given in Dr. Watt's Dictionary is rather conflicting, but as this is the only authority we could lay hold on, we would quote a passage here from his Dictionary :—"The produce has been estimated in Ceylon at 10 tons of green roots per acre. This weighs one-fourth when dried, and if the dried roots gave half their weight of flour it would amount to 2,800 lbs." This means 34 maunds per acre, which, of course, is three times as much as one gets out of an acre of paddy or wheat.

761. Though Cassava can be planted at any season, and harvested at any season, which is a great advantage looking at the question from the point of view of famine prevention only, the best season for harvesting, and consequently of replanting of cuttings, is February and March. There is

now one point which must strike one very forcibly, *viz.*, that Cassava which yields 50 maunds of flour and meal per acre besides leaves &c., must be an exhausting crop, and the produce must fall off very much after the first year. If no manure is used the produce is bound to fall off. But if one were to expect a crop of Rs. 300 per acre, one ought to spend Rs. 20 or Rs. 30 per acre after the first year on manures. A handful of ashes is the only manure that need be used while planting the cuttings and the exhaustion can thus be easily recuperated.

762. When one is working on a large scale one cannot depend on knives for slicing roots, and quirns for grinding the dried pulp into flour. But cultivators need not work on a large scale. They can grow the plants in small patches and utilize the roots either for eating them fresh, or converting them into flour by such simple processes as we have described. If a capitalist is to launch out on an extensive scale, he must use machinery for slicing, pulping, pressing and grinding. If one were to grow Cassava on a moderate scale, say, on 5 or 10 acres of land, one must use such simple machinery as turnip-slicer, turnip-pulper, cheese-press and a small grinding mill to cope with the work of harvesting. The cultivator will need nothing that he cannot easily procure in his own village or even in his own cottage ; *gamlas*, and *dao* and *dhenki*, and a couple of big stones, are all the special appliances required.

763. The next question one would be interested in is, how to make use of the produce when one has got it. Tapioca-pudding is used as a nourishing food by Europeans, but this would not probably be relished by Indians. But tapioca-meal can be used in place of arrowroot. It is more nourishing than arrowroot. Cassava flour is still better as an article of food suited to Indian taste as it can be utilized in making various articles of food which we are ordinarily in the habit of eating. Out of Cassava flour may be made

chapatis, puris, malpoas, halua, puddings, and biscuits. It does not make very first class *chapatis, puris,* and biscuits, but it makes excellent *malpoas,* and *halua,* and Cassava-pudding tastes nicer than tapioca-pudding. The *chapatis* are very palatable, but they are a little too elastic, though quite soft. For making dough, hot water should be used: otherwise Cassava flour and wheat flour are used exactly in the same way. In making *halua* out of Cassava flour the syrup has to be made first over a fire, with sugar and water. When the syrup is somewhat sticky, a proportionate quantity of Cassava flour mixed up with water is put in. The flour should be mixed up with the syrup by prompt stirring. When the colour of the flour changes, a little ghee and almonds and pistachio nuts are to be added and the mixture kept stirred for another few minutes. The *halua* thus made keeps long and it tastes very much like Muscat *halua.* In making 100 tolas of *halua* 13 tolas of Cassava flour mixed with 40 tolas of water should be used. The syrup is made with 40 tolas of sugar and 20 tolas of water. Ten tolas of ghee and an anna's worth of almonds and pistachio nuts are used for giving the *halua* a rich taste. It is a cheap and delicious sweetmeat. Frozen with ice it is further improved. In making biscuits, three-fourths Cassava-flour and one-fourth wheat flour should be used.

764. The Cassava roots could thus be variously used, and the poorest and the most epicurean can make use of them either in their fresh state or manufactured into flour. The well developed roots weigh 2 to 5 lbs. each, and they can be eaten either raw or cooked (*i.e.* either boiled, or fried in chips or curried). As a drought-resisting crop, as a heavy yielder, as a nourishing food-stuff which is easily manufactured, we do not know anything which comes up to Cassava.

765. The roots, tasting quite nice when raw, are very much liable to the attack of rats. Some arrangement must

be made for poisoning rats if the crop is to be secured undamaged and undiminished.

766. Of other drought-resisting root-crops, may be mentioned the *ól*, yams and a bulbous vine grown at Kalimpang called Ish-kosh. The *ól* of Bolepur, Santragachi and Geonkhali are famous. Of yams may be mentioned an African yam which is grown at the Sibpur Farm and which is almost as good as potatoes. The elephant's foot yam of Malabar is also famous. The leaves of Ish-kosh are eaten by cattle while the edible roots sometimes weigh 1 to 2 maunds from under each vine.

CHAPTER LXXIX.

ARROW-ROOT.

THE arrow-root is extracted from the bulbs of various plants: —(1) The common Bermudas arrow-root is obtained from Maranta arundinacea. This is the common arrow-root which we have seen growing at Alipur and in some Jail gardens. The plant grows 2 to 3 ft. in height; the flowers and the tubers are white. (2) The Brazilian arrow-root extracted from Cassava roots which we have already described. (3) There is another variety of arrow-root grown chiefly in Queensland from a Canna, the flowers of which are beautiful bright scarlet not unlike Indian shot flower. The plants of Canna edulis grow 8 to 9 feet in height and from a single stool 15 to 20 stalks come up, each stalk bearing a big bulb. 60 to 80 lbs. of bulb are often extracted from a single stool. The starch or arrow-root extracted from this plant is known as *tous-les-mois*. Rich

alluvial jungle land, or river or creek banks suit this plant best. It is also grown in open countries on rich deep soils. It prefers a more sandy soil than the ordinary arrow-root Maranta arundinacea. The bulbs are sold in Queensland for £2. 10*s.* per ton and the arrow-root extracted from it sells at about 9*d.* a lb. Ordinary arrow-root prefers shade, and the bulbs of this are planted about a foot apart in the lines and 1½ ft. from line to line. In growing Canna edulis, burn the jungle, make hole 6 or 7 ft. apart in rows and 4½ ft. from each other in the lines. If plough can be used ploughing and pulverising and trenching 6″ deep and planting 4½′ apart of single bulbs should be done, the rows being made 7′ to 8′ apart. As the land gets poorer by cropping the rows should be made closer but never closer than 6′ apart, the hilling or earthing once is all the subsequent operation needed. The roots are dug up from December to February *i.e.*, 9 months after planting, the planting being done in March or April. Ordinary arrow-root does better planted in May or June.

768. A good test for ascertaining when the ordinary arrow-root bulbs are ready for harvest is to observe at the outer leaf of the bulb a triangular slit pointing downwards; if the slit is white the bulb is still immature; as soon as it turns purple it is ready for harvest. It can be left for 2 seasons as sugar-cane is sometimes left.

769. Each day's digging must be operated on on the same day. Every day of exposure to sun and weather has an injurious effect upon the colour of the manufactured starch. 12 to 40 tons of *tous-les-mois* bulbs per acre are obtained if the plants are 5′ by 6′ apart. 15 to 30 cwts. of starch per acre is the average produce. Up to 4 tons have been obtained. The price of arrow-root in London market is £15 per ton. If machinery is used 10 to 30 cwts. of arrow-root can be extracted per day. For a mill capable of turning out 30 cwts. of arrow-root per day, the following appliances are necessary; one root-washing tank, one elevator, one grater or

grinding mill, rotary sieves, shaker sieves, one chute, one agitator, one centrifugal pump for draining water from vats. Tables and calico for drying the roots are raised to the highest part of the building. The cost of erecting an arrow-root mill is about Rs. 18,000, plus Rs. 3,000 for drying and storing shed.

CHAPTER LXXX.

PROPAGATION OF TREES FROM GRAFTS &c.

THE *object* of grafting, budding etc., is to propagate any given variety of fruit *true to kind*, or to convert unsuitable or unprofitable varieties into suitable or profitable ones. Grafting differs from budding in that, in the latter operation, a bud only is taken, whereas in grafting a portion of the previous season's wood that is well ripened, and containing from one to four or more buds, is used. Budding can be successfully carried out only when the stock is in a state of active growth; but grafting, other than bark (or rind), grafting is most successfully carried out in spring, just previous to the commencement of active growth.

771. Grafting is applicable to fruit trees of all kinds and sizes, from nursery stock to large trees, different methods being used for different kinds and different sizes of trees.

772. The following tools should be obtained for grafting:—1st, a strong pruning knife, having either a straight or curved blade, Saynor's knives being preferred to all others by professional gardeners.

2nd, a knife having a thin straight blade with which to prepare the scions; the knife used for budding will answer for this purpose also, if sufficiently strong.

3rd, a good pruning saw, such as the "California" or a common hand-saw, if the trees to be grafted are of large size.

4th, a strong chisel and wooden mallet for preparing large stock.

5th, a grafting pot in which to prepare the grafting wax. An ordinary glue pot will answer.

6th, bee's wax, tallow, resin and turpentine.

7th, thin calico, cotton wick, plantain fibre and moss, or Jadoo fibre.

773. All appliances should be kept clean and sharp as the cleaner the cut the more complete is the union.

774. *Grafting wax*, which is used for all grafts above ground, is made in several ways. For root-grafting and saddle-grafting, where the earth is brought round the union (Fig. 59B), no wax is used. In root-grafting even tying is not necessary; but in saddle-grafting, the stock and the scion must be tied together firmly before the earth is brought round the union. One recipe consists of melting together, over a slow fire, equal parts of bee's wax, resin and tallow till dissolved and thoroughly mixed, when it is ready to apply, and another good recipe is the following:—

Bee's wax	... 1 lb.
Tallow	... ½ lb.
Resin	... 1 lb.
Turpentine ...	... 2 ozs.

Melt the resin and tallow over a slow fire; then add the wax, and when melted mix well together. Then add the turpentine and stir well, when it is ready for use.

775. Grafting wax is applied hot with a brush to the graft when tied in position, care being taken to cover the wound completely so as to exclude the air. A simple and convenient way of using the wax in the case of nursery stocks, is to dip a sheet of thin calico into the boiling wax and when sufficiently cold, tearing the waxed calico into narrow strips of suitable length. The graft being placed in position

the waxed tie is wound round it so as to completely cover the union; the heat of the hand being sufficient to soften the wax, so that it sticks well and is air-tight.

776. The *principle* underlying every method of grafting is to so unite the scion or graft with the stock as to bring the cambium layer or wood-producing layer of each, together. When the two layers are brought together and kept together without air they each throw out new cells which join together and form one layer of wood.

777. There are various modes of grafting, known variously as Bark-grafting, Cleft or Wedge-grafting (Fig. 59 C),

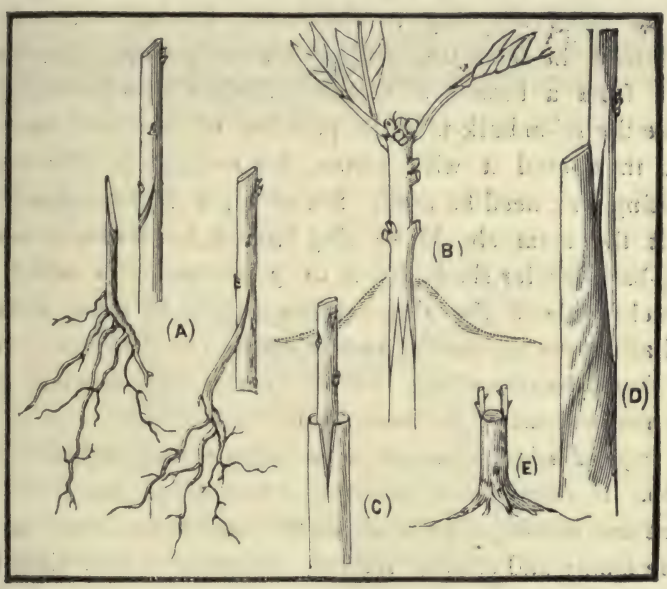


FIG. 59.—GRAFTING.

A.—Root-grafting. C.—Cleft or Wedge-grafting.
B.—Saddle-Grafting. D.—Whip or Splice-grafting.
E.—Crown or Rind-grafting.

Crown or Rind-grafting (Fig. 59 E), Saddle-grafting (Fig. 59 B), Whip, Splice, or Tongue-grafting (Fig. 59 D), the principle underlying being the same in all cases. Root-grafting (Fig.

59 A) is also practised by gardeners. A small piece of root is either grafted on to a scion of the desired variety or the scion is grafted on to the root-stock just below the ground where the stock is.

778. *Bark-grafting.*—The bark taken from scion may have one or several buds on it. When one bud only is used, the operation is called *budding*; when several buds are used the operation is called *bark-grafting*, or *multiple budding*. Either old or new bark answers, but old bark does better. The length of bark taken should be twice that of the breadth (circumference in the case of bark-grafting). There should be no wood adhering to the bark. Having secured the bark from the scion tree, cut out a corresponding portion of bark from a branch of the same thickness on the stock and make the scion bark take the position of the bark thus cut out, then bind it with cotton, but not tightly. No clay or grafting wax need be used. Six or eight inches above this graft the stem should be ring-barked, but leaves above the ring-bark left for shade for 2 or 3 weeks, after which the branches above the ring-barking should be cut or sawn off and all shoots appearing, except those on the bark grafted on, should be rubbed out, that all the ascending sap may go to the nourishment of the buds on the bark.

779. *Budding* proper is a simple but delicate operation. It consists of removing a bud (Fig. 60) from one plant and making it grow on another which must be of the same family and closely related, although it may yield fruit or flowers of an inferior character. It is possible to bud an orange on a lime tree and a peach on an English plum tree, but not a rose on an orange. But very curious combinations are being now achieved by budding. A single bud is carefully removed from the tree to be propagated by inserting the budding knife about half-an-inch above the bud, and cutting slightly inwards and downwards, bringing the knife out about $\frac{1}{2}''$ below the bud. If there

is a leaf under the bud it is first to be cut off carefully. The little bit of wood that will come along with the bud and the bark will be found in the middle of the scion immediately behind the bud. This bit of wood is carefully removed with the knife without cutting into the bud from behind. A T-shaped cut is then to be made in the stock not deeper than the bark, that is only the bark is to be slit open, and the scion introduced carefully into the longitudinal portion of the slit, the operation being helped with the insertion of the thin ivory handle of the budding knife between the bark and the cambium of the stock on both sides of the slit. When the scion has got right in, only the bud peeping out of the slit, the cut edges are to be closed over and tied with plantain tree fibre. From the beginning of the monsoon to November and December, is the proper season for budding.

780. *Layering.*—This is another method (Fig. 61) of



FIG. 60.—BUDDING. FIG. 61.—LAYERING.

propagation. If the branches to be layered can be brought down to the ground, a slit should be cut at the firmest part that can be made to touch the ground by inserting the knife at the lower side near to and beyond a bud and cutting nearly to the centre of the branch, drawing the knife towards the end of the branch about an inch or more. A small stone should be placed in the slit and the cut portion covered with sand or powdered brick. A good sized stone should then be put on the bend so as to keep the layer steady, and water supplied as the soil gets dry. When a branch cannot

be brought down to the ground arrangement may be made for taking pots of soil to the branch and keeping the layers moist high up.

781. *Inarching*, or grafting by approach, is the commonest method practised in this country. It consists in bringing a second year's seedling or plant from cutting obtained from an easily propagated and wild or inferior plant, in a pot, properly rooted, to the tree from which the scion is to be obtained, and placing it in such a position (on a platform, or within the embrace of a bamboo split at the top, for instance), that the portion of the tree of the superior kind which it is desired to propagate, can be brought into direct contact with it. A thin slice is then taken off one side of the seedling or wild stock about 2 or 3 inches in length, and a corresponding slice is taken off the branch of the tree that is to be used as scion, the two branches being of the same diameter. The cut surfaces being placed together, it is seen that the inner barks on both sides of the cuts join, the two being firmly tied with soft cloth. The graft is not waxed but is kept moist by water constantly dropping on to it. When union has taken place (which it does completely after several months) the scion is severed very carefully from the parent tree and the young plant is ready for removing. It is not easy obtaining successful grafts by this method.

782. *Propagation from cuttings* is possible in the case of some plants and trees. Well ripened branches taken from near the ground, at a joint, *i.e.*, where one branch joins another, make the best cuttings. There should be about 3 joints in length cut close beneath a bud and inserted about one-third of their length in fine sandy soil or brick-dust. In dry season, in Lower Bengal, when it is inconvenient to keep the soil watered, and when the cuttings are known to send out shoots freely, *e. g.*, in the case of sugar-cane, rhea and cassava, planting may be done horizontally 3″ or 4″ under the surface of the soil. Cuttings should be planted as fresh as possible, though

some cuttings (*e. g.* those of mulberry, cassava and sugar-cane) are known to retain their vitality for more than a month kept in a damp and shady place. Where there is uncertainty, the additional precaution, of dipping the fresh cuttings in camphor water immediately before planting, should be taken.

783. *The Gootee system of propagation.*—This is another method which is commonly employed in this country for propagating orange trees, India rubber trees (Ficus Elastica) &c. Hundreds of *gootees* may be formed on one tree without doing the tree much harm. At the commencement of the rainy season, healthy and mature stems are chosen, and a ring of bark, 1 to 3 inches in length according to the thickness of the stem chosen, cut out. The bark should be cut out immediately below a leaf-bud. A ball of clay made sufficiently plastic by working it well between the palms is then put round the ring-barked portion, so as to completely cover it.

784. *Pruning.*—Experience alone can decide for each class of fruit trees, whether annual pruning of branches, or pruning every alternate year, or root-pruning, best answers for encouraging the growth of fruits. In the case of mangoes root-pruning has been found more useful than branch-pruning. In the case of mulberry trees grown for leaves for silkworms, pruning of branches every alternate year has been found the most economical way of dealing with them.

CHAPTER LXXXI.

INDIA-RUBBER AND GUTTAPERCHA.

THE annual consumption of India rubber in the world is about 60,000 tons valued at Rs. 100 per maund. Great Britain imports the largest quantity. The principal sources of India-rubber are Africa, Central and South America, Ceylon,

Assam and Burmah. It is the hardened latex obtained from various families of tropical plants, both trees and shrubs, while guttapercha is the hardened latex from large trees belonging to one family only, viz., Sapotaceae. Both India-rubber and guttapercha consist of carbon and hydrogen. India-rubber does not soften in moderate heat like guttapercha does. India-rubber is impervious to water, alcohol, most acids and gases and it retains for a long period its original elasticity and strength; while guttapercha becomes soft and plastic in hot water retaining any shape given to it on cooling when it becomes hard and rigid.

786. The most important India rubbers are :—

(1) *Para rubber.*—This is obtained from Hevea Brasiliensis, a South American tree which grows in Ceylon. Para rubber does well in Ceylon in low elevations in certain districts, but not so well as in the Straits Settlements or in America. It is ready for tapping in 15 years. The tree attains a height of 60 ft. and a girth of 6 to 8 ft. The wood is poor, soft and easily perishable. The seed is very oily and on this account easily gets rancid and spoilt. But it went from Ceylon to Kew Garden all right packed in canvas bags only, and it travels better packed in moderately dry soil or cocoanut fibre. It is propagated also from cuttings and stools or green shoots. The tree grows in well drained soils beyond the reach of floods, although in South America it flourishes in unhealthy localities which get annually inundated and swamped. The latex is alkaline and the addition of a solution of ammonia preserves it indefinitely from spontaneous coagulation. In favourable localities, 120 to 140 lbs. of para rubber are obtained per acre per annum after the 10th year. The tapping commences sometimes on the 6th year, when each tree yields about 10 ounces. If 300 trees are planted per acre as much as 188 lbs. can be obtained out of an acre from 6-year-old trees, but 300 per acre (*i.e.*, when they are 12 ft. apart)

are too many, when the trees are older, and they have to be thinned out. At 1*s.* 6*d.* a lb. the yield per acre would be about Rs. 112 and the margin of profit may come to half this amount.

(2) *Ceara rubber* is the product of Manihot glaziovii, a plant which resembles the cassava. The experiment of growing this in Ceylon has failed. The tapping hardly paid for the weeding, and after 6 years the plants were too dry to yield rubber. The bushes can however be grown for their roots which yield a valuable starch like the ordinary cassava.

(3) *Ule tree rubber*, which is almost as good as para rubber, is the product of Castilloa Elastica (belonging to Moraceæ), a Central American fast growing tree, allied to the bread-fruit tree. It is easily propagated from seed or cuttings. 7 or 8-year-old trees yield 1 to 2 lbs. per annum, 25 % of the milk being pure rubber, separated by centrifugal machine. This tree has been also introduced into Ceylon, but experiments so far have not given encouraging results. Castilloa milk flows more freely and does not coagulate readily, which is a great advantage when a centrifugal machine is used. No return can be expected within 8 years after planting. The Castilloa successfully introduced into Ceylon in 1876, is the C. Markhamiana, from Darien (Panama). They flowered in 1881. The growth since 1886 has been slight. It does well in warm, steamy, alluvial localities and does not do well in elevated tracts nor in swamps. The temperature should never fall below 60° F, the rainfall should not be below 70 inches, and it should be well distributed. It should be planted in sheltered places near streams, but where the land is well drained. Para rubber does well in wetter places. The seed should be sown in a well prepared nursery 1″ deep and 8″ apart and lightly covered with vegetable mould. The nursery should be kept lightly shaded and watered and in 10 or 12 months when the seedlings are 2 ft. high they are

planted out. Cuttings from main shoots (not lateral branches) also take. Planting should be done 12″ apart and the plants left in shade for 2 or 3 years. Weeding and watering have to be done until the plants can take care of themselves. When trees have attained a girth of 2ft. or 2½ ft., they can be tapped. Cuts should be 3′ or 4′ apart and not 1′ apart as in Para rubber trees. 5 ozs. per tapping may be obtained and 3 or 4 tappings per year.

(4) *Indian rubber* is the product of Ficus Elastica, Artocarpus Chaplasha, Artocarpus Integrifolia, and Alstonia Scolaris. The last is a large tree which grows 60 ft. high in the dry forests of Ceylon, Singapur and Penang.

787. In a Ficus Elastica plantation, 35 years old, the average yield per tree per year is 600 grammes of solid rubber. The variation in yield, however, is very great. One tree may yield 100 grammes another 12 kilogrammes. The average yield of Castilloa rubber in the same plantation (the plants being 8 years old) is 200 grammes of solid rubber per tree per year. But as there could be about 4 times as many Castilloa trees planted in the same area as Ficus trees, the difference in favour of the Castilloa is decidedly considerable. Castilloa rubber is also more valuable and it can be gathered from much younger trees.

788. It is from the Government Forests of Ficus Elastica in Assam that most of the Indian rubber (not Ceylon rubber) is derived. The latex is collected during the dry months. Eight oblique cuts are made with the *dao*, sloping downwards at a little distance from one another, so that 8 *kalsies* can be tied round the tree one below the other. These remain on the whole day. The cuts should not be deep as the milk is secreted just below the outer bark A great number of incisions should not be made on each tree as they weaken and ultimately kill the tree. The incisions should be made only on the main stem the lowest one being made about 4 ft. from the ground.

789. A little powdered alum should be taken in a tea cup full of water and mixed well. A few spoonfuls of this solution should be put into each vessel containing about 3 bottlefuls of the milk after straining the milk from extraneous matter. The milk will coagulate immediately. the rubber is then exposed to air on sticks and allowed to drain for a week. After a month it is ready for the market. A simpler process of extraction of rubber from the bark and roots of the tree has been recently discovered. This consists in keeping the slices of bark and roots soaked in dilute sulphuric acid, first heated. The woody portions are decomposed, when they can be washed out, leaving the rubber in a pure state.

790. The price has varied from Rs. 20 to Rs. 120 per maund within the last 20 years. A full grown rubber tree 50 years old, yields at the very lowest, 5 seers of rubber each time, if very carefully tapped, and this quantity may be expected about 16 times in 16 successive years, which is a safe estimate for calculating the yield of a rubber tree. At the rate of 10 trees per acre, the yield comes to 20 maunds of rubber per acre in 16 years valued at Rs. 2,000. While an acre of timber at Rs. 10 per tree would bring only Rs. 500 or 600. It is only Government or very rich landlords who can afford to wait for 50 years before the return comes, but the propagation of India rubber trees should be always kept in view by Managers of Government and Court of Wards estates, where immediate return need not be looked for. The seedlings may be grown either on mounds, or as epiphytes on other trees.

791. The fruits of a Chinese plant, Enconia illinoides, yield a very high proportion of rubber.

CHAPTER LXXXII.

THE BAMBOO (BAMBUSA ARUNDINACEA).

ALLUVIAL loam is best adapted for the growth of this plant. There are various *jats* of bamboo, solid and hollow thick and slender, strong and brittle, fast-growing and slow-growing. The right variety should be chosen. Holes are to be dug in May, 20 feet apart, and rotten cattle-manure put in the holes. In June or July, bamboos with roots are to be dug up and planted, slantingly, in the holes. In the first year, in the dry season watering will be necessary from time to time, but afterwards only an application of silt or ashes, once a year, in April or May, is all that is required to be done to keep the clumps in vigour. Cutting of ripe culms can begin from the 5th year, two or three being cut out of every clump the 5th year, and the number gradually rising to 8 or 10 per clump per annum. A clump of bamboo may go on yielding for 40 or 50 years, 8 or 10 bamboos a year, if the annual application of silt continues. An acre of bamboo forest may yield a gross income of Rs. 200 per annum, after 10 years, and Rs. 100 per annum after 5 years. Young shoots of bamboos are boiled and cooked like vegetable.

CHAPTER LXXXIII.

ORANGES.

THE four principal localities in which oranges are regularly cultivated in plantations, are, Sylhet, Sikkim, Delhi, and Nagpur. We get four different varieties of oranges from

the four localities, the differences being, no doubt, due to difference in climatic conditions. A moderate degree of cold during a fairly prolonged period, say from November to April, is needed for the proper growth of the trees and the proper formation of fruits. We have known of persons taking the trouble of importing along with orange seedlings from Sylhet as much soil as practicable to give the seedlings, as they thought, a good start in the soil of Calcutta. But it is the climate and not the soil that makes the difference. A plantation of orange trees should be protected from strong breeze, specially strong sea-breeze. Screens of living forest are the best. The soil should be well drained and above inundation level and fairly rich, that is, richer than soils chosen for growing timber trees. If chemical analysis is possible, it should be ascertained if the soil chosen is particularly rich in lime and phosphates. Nepaulese cultivators put bones of animals in the hollow where an orange tree is transplanted. If the soil is not particularly rich in phosphates this method should be followed. The holes where orange seedlings are transplanted should be made pretty wide, say 5 or 6 ft. in diameter, though they need not be made deep as the roots of the orange tree do not penetrate very deep into the soil but have a tendency to spread laterally. Rotten manure should be put in the holes in addition to whole bones. The planting should be done 20 to 25 ft. apart, in regular lines. Seedlings do better ultimately than grafts, though the latter bear fruit earlier. Seed should not be gathered from grafts which may have had a lemon or a citron stock, as the result from such seed might or might not be true orange but a hybrid. Mature, full grown and earliest fruits from the topmost branches should be gathered for seed. Only those pips should be chosen which are round and large, flat and shrivelled seeds being rejected. The seed should be sown in drills 3 inches deep. The seed-bed should be protected with mats, in the usual way, from sun and rain. The seedlings should be left

for two years in the seed-bed before they are transplanted. Transplanting should be done at the dormant period of the plants, *i. e.*, when only old leaves abound on the seedlings and when growth is not going on vigorously. Injury to roots, specially the tap-root, should be avoided as much as possible, in lifting the seedlings. Water-logging at the base, after transplanting, must be avoided or else the seedlings will sicken and die. If there is considerable injury to roots at the time of transplanting, some of the branches and most of the leaves should be cut off. October and November are better months for transplanting than June and July. In the former case, however, irrigation or watering will be needed until next May or June. The other operations that help growth of the plants are hoeing and mulching (straw or litter being applied). Mulching protects the plants from the effect of excessive heat and drought, and also prevents caking of the soil. The mulch should be applied after the hoeing, and watering should be done over the mulch.

794. We have no very superior varieties of orange in India. The seedless orange of California is the best variety to grow. This must be propagated by budding or grafting. The importation of this variety and its acclimatization by budding or grafting on the wild orange of Sylhet or Sikkim, are desirable. The net profits from an acre of seedless oranges in California often come up to 250 to 300 dollars (about Rs. 800) per acre, and there is no reason why some Indian planters should not make a new departure in this direction.

CHAPTER LXXXIV.

LAC.

BESIDES tea, coffee, indigo, India rubber, vanilla, cardamom, cinnamon, round pepper and oranges, European planters in India have tried more or less successfully the culture of silk and lac. Bee-culture has not prospered as the imported bees from Italy ate far more sugar than could be reasonably supplied to them, and the different varieties of Indian bees have been found too wild for domestication and artificial rearing. The subjects of silk and mulberry had been treated by the author in a separate Hand-book, and of planting subjects lac alone remains to be treated.

796. Lac is a resinous incrustation formed on the twigs of *palas*, *bar*, *gular*, the *peepul*, *arahar*, *phalsa*, *baer*, *babul*, croton and other trees and shrubs, by an insect (coccus lacca) belonging to the natural order Hemiptera, nearly allied to the cochineal insect. There are more than one species of lac insects. In October or November the inoculation of trees with this insect should be done. Twigs encrusted with the resinous nests of the insect are cut up into small bits, put in mosquito net bags and hung up in different parts of the trees. The minute red coloured larvæ of the coccus lacca escape from their eggs and crawl about in search of fresh sappy twigs. When satisfied, they become fixed and form a sort of cocoon by excreting a resinous substance. The male cocoon is ovoid in shape, the female circular. For about two and a half months the insects remain within their cocoons in a lethargic state, but structural changes have been accomplished by which they have reached the mature or imago condition. The male escapes from the cocoon by backing out at the ventral opening. The female has also become mature, but since it is

destined to remain in its present position, it renews activity and commences to throw up around itself a more perfect coating of resin until its body becomes completely incrusted. The proportion between male and female is about 1 : 5000. The female, after depositing her eggs below her body, commences to construct cells round each with as much precision as the bee forms its comb. As time advances, further changes are visible; the body of the female enlarges considerably and becomes brilliantly coloured. The red colour is due to the formation of a substance intended as food for the offspring. The eggs germinate below, and the larvæ eating their way through the body of the mother, make their escape to repeat their cycle of existence.

797. After inoculation the insects have to be guarded against ants. If this is neglected the struggle for existence usually results in the complete extermination of the lac insect. Another cause of failure is inoculation in the rainy season, instead of in the dry season. The heavy down-pour of rain gradually washes away the insects when they are few in number. When they have once established themselves in a plantation, rainfall or ants do not do any noticeable harm.

798. The colour of the lac resin varies from a bright orange to a darkish garnet according to the particular species of tree or shrub, on which it is grown. Thus the Schleichra trijuga (Kusumb of Manbhum) yields lac of a bright orange colour, while Butea frondosa (palas) yields a dark garnet coloured lac. The grewias (Phalsa tribe), ficus, cajanus indicus, *baer* and acacias give intermediate tints. The value of the tint depends on the brightness of its colour. The relative proportions of resin and lac-dye secreted by the insects are also affected by the species of tree on which they feed. Dr. Watt attributes differences in the quality of lac to actual difference in the species of lac insects.

799. Lac is obtained in a perfectly natural or wild state in the forests of India, Burma, Siam and other countries, the

insects being conveyed from tree to tree by birds and larger insects, also by wind. It is most plentiful in those districts which have moist climate and few hot winds. Thus Assam, Burma, and the forest districts of the Central Provinces and Nagpur, and also perhaps Mysore, are the chief sources of its supply. The natural yield is augmented by people fastening pieces of mature lac, from which the insects are ready to emerge, on fresh trees of suitable species.

800. The *arahar* plant yields well and attains sufficient size in 12 months for inoculation, but it requires to be resown every 2 or 3 years. It does not stand drought well and any damage to its roots by hoeing or otherwise, causes it to die. Some of the ficuses grow fast from cuttings but are not very satisfactory as lac producers. The Scliechra requires 7 or 8 years at least before it becomes large enough to support insects, and on the whole the grewias are the best.

801. There are usually two crops of lac during the year and sometimes three. The twigs are collected and scraped, the lac broken up, passed through a sieve and washed in many changes of water, until none of the red colouring matter remains. It should then be a bright orange, and almost completely soluble in alcohol. It may be exported in this form, when it is called 'seed lac,' or it may be converted into shell-lac by mixing it with a small quantity of ordinary resin and melting it in cloth bags; the molten lac passing through the interstices of the cloth is spread out in thin sheets on a semi-circular surface.

802. The prices obtained for 'seed lac' of good quality are very nearly as high as those for good shell-lac, and European traders are learning to prefer the former, as it is absolutely free from resin adulteration and gives a harder lacquer for the Birmingham brass workers.

803. An 80 acre plantation of Grewias planted 12 ft. apart, or 302 per acre, would have 24,160 trees. Each tree would yield about 4 lbs. of clean seed-lacs, or from the whole

area, say, 96,640 lbs. or 863 cwts. may be expected. In round figures 500 cwts., in October (*i. e.*, the rainy season crop) and 200 cwts. in May (*i.e.*, the cold weather crop), or 700 cwts. in all, at 50 shillings per cwt., amounts to £1,750. The following calculation for expenditure is the result of an actual experiment conducted by an Assam planter (writing in the Englishman newspaper).—

	Rs.
Rent at Rs. 3 per acre for 80 acres	240
Hoeing or cutting jungle between trees	320
Up-keep of necessary buildings	100
Cutting branches and putting on seed	340
	1,000
Manufacturing charges at 5 %	3,500
Packing, and despatching, at 2½%	1,750
Calcutta charges for forwarding and river freight, at 2½%	1,750
London charges for sea freight, dock, and brokers' charges	3,000
TOTAL ...	11,000
Proceeds of sales £1,750 at 14*d.*	26,250
Deduct discount to buyers	656
TOTAL ...	25,594
Deduct expenditure	11,000
Balance Profit	14,594

804. Lac worked in connection with tea &c., the amounts for European and native supervision, and up-keep of cooli lines &c., may be added proportionately according to circumstances.

805. The planter referred to, however, lost nearly his whole crop next year from the attack of the night-moth, Finetes, belonging to the Nocturanæ which deposits its eggs on the immature lac insect. The larvæ of this moth on

hatching burrow through the cells eating the red colouring matter and destroying the resin.

806. *Lac dye.*—The powdered encrustation of the twigs being triturated with a liberal supply of water, the colouring matter passes out in the water. This water is run off into a vat and allowed to remain there till the dye is precipitated, looking like dark mud at the bottom of the vat. The surface water is then run off and the precipitate placed on cloths which are laid in frames 18″ square, having compartments about 1½ inch square. When the muddy precipitate is tolerably consistent, the compartments are filled with it and the frames put into a screw-press. The water being expressed out, the firm cakes are placed on a clean floor and dried thoroughly when they are fit for the market.

CHAPTER LXXXV.

AGRICULTURAL CALENDAR FOR LOWER BENGAL.

JANUARY.—Sugar-cane harvesting and *gur*-making. Sowing of *kulibegun* and *deshi* onion seeds. Planting of *ôl* for the August to September crop. Final irrigation of potatoes, cabbages and other English vegetables. Picking of cotton bolls. Pitting of sugar-cane cuttings, or 'topping' of seed-canes. Harvesting peas and *Kalai*. Preparation of land for sugar-cane and cucurbitaceous crops. Transplanting of *deshi* onion. Sale of English vegetables.

February.—Harvesting linseed, mustard, *mung* and *til*. Sugar-cane harvest and *gur*-making. Planting of sugar-cane and sowing of cucurbitaceous crop seeds (*ucche, jhingá*, water melon, mash melon, gourd, pumpkin &c.). Transplanting of *kulibegun*. Preparation of land for *Kharif* crops. Sale of English vegetables. Picking of cotton.

March.—Harvesting of barley, oats, wheat, gram, *musur*, *khesari* and of other pulses. Planting and irrigating sugar-cane. Watering and manuring (chiefly sprinkling ashes on) cucurbitaceous vines. Picking of cotton. Sowing cotton seed and maize if there is a heavy shower of rain. Preparation of land for *kharif* crops.

April.—Watering of sugar-cane and cucurbitaceous vines. Planting of yams and *ól* for the December crop. Sowing of maize, *juar*, reana, jute, and *mestá pát* seeds, after a good shower of rain. Manuring of mulberry, plantain, bamboo and other perennial plants with tank or canal silt. Manuring *Aus* fields with cattle dung, village sweepings, tank-silt, weeds or compost. Sale of cucurbitaceous vegetables. Preparation of land for brinjal and sowing of seed.

May.—Sowing of *Aus* paddy, maize, *juar*, *dhaincha*, *arahar*, reana, jute. Sale of cucurbitaceous vegetables. Transplanting of brinjal and cotton plants, if heavy showers of rain obtained. Earthing of maize, *juar*, and reana if sowing done in March or April, or sowing of seed of these, if heavy showers not obtained in March or April. Final preparations for *Kharif* crops generally. Sale of cucurbitaceous vegetables. Sowing of cucumber, gourd and pumpkin seeds. Final manuring, earthing and irrigation of sugar-cane.

June.—Sowing of *Aman* paddy. Transplanting of brinjals and cotton, if not done before. Planting of plantain and other trees in *Aus* paddy fields. Weeding of *Aus* paddy, *arahar,* jute and *mestá pát.* Sale of green cobbs of maize. Earthing of brinjals and cotton, if sufficiently forward. Sowing of edible hibiscus, *arahar,* turmeric, ginger, *kachu,* yams, sweet potatoes, *sankalu, ságs* (amaranths &c.), and ground-nut, may take place in May or in June. Gourds, pumpkins, *jhingá* and cucumber seeds may be sown in this month also. *Bhadai kalái, bhringi, kurthi, arharia sim, popat* beans and country beans may be also sown this month. Guinea grass may be planted or the plantation extended.

July.—Transplanting of *aman* paddy. Sowing and planting of chillies. Planting of trees, specially cocoanut, bamboos. Weeding of cotton, earthing of brinjals, turmeric, ginger &c. Sale of green cobbs of maize. Weeding of jute, *arahar* &c. Tying of sugar-cane. Letting out of water from *arahar,* cotton, sugar-cane, *juar,* reana, jute, *kharif* pulses, *ól,* yams &c., and keeping water in *aman* paddy fields.

August.—Harvesting of *Aus* paddy, leguminous and other fodder crops generally. Sale of brinjals, *shim, ságs* and country vegetables. Earthing of chillies, cutting of *dhaincha,* jute, *mestá pát.* Washing of the fibres of the two latter may also commence this month. Sowing of seed of English vegetables in verandahs.

September.—Preparation of land for *rabi* crops. Harvesting of maize, *Aus* paddy, and *Bhadai* pulses. Tying of sugar-cane. Country beans and peas, *Pálam ság, Chuká pálam, Kanak note ság,* radishes, pumpkin, gourd, and early cauliflower (Patna seed), also turnip and *til* to be sown, cauliflower

alone being sown in seed-bed under cover, the rest in well drained fields. Palval and sweet potato cuttings may be also sown. Land to be got ready for the regular English vegetables and seed-beds prepared. Transplanting of trees and seedlings (*Papaya,* plantains &c.). Picking of cotton bolls. Sale of jute and vegetables.

October.—Sowing of English vegetables generally, cabbages, cauliflower, knol kohl, artichoke (on sandy loam) Brussels sprouts, turnips, celery, lettuce, tomatoes, radishes, carrots, onions, French beans, peas, potatoes, sweet-potatoes (batatus edulis) and palvals, to be sown. Last month's sowings to be protected from water-logging. Early cauliflower to be transplanted and protectod from the sun. Brinjal and cotton fields to be dug, also sugar-cane field. Bases of plantain and other trees to be loosened and raised, and a basin for holding water made round newly transplanted trees. Preparation of land for *Rabi* sowings generally to go on vigorously during this month, as in most places in Lower Bengal preparation in September is not feasible, the rains usually continuing to the end of this month or even to the middle of October. Sowing of gram, linseed, *til, khesari, musuri,* and *mung* to be got through before the end of this month, if possible. Picking of cotton bolls.

November.—Bases of trees, cotton and brinjal plants, may be loosened and cleaned during this month also. Barley, oats, pulses, and mustard to be sown, and then wheat. Sowing of English vegetables and potatoes may continue. Radishes, cotton, melons, gourd, cucumber and other cucurbitaceous crops, coriander, onion and

pulses, including Vigna catiang, may be sown during this month. Hoeing of early sown plots and irrigation of potatoes, cabbages and cauliflowers may be necessary. Winter paddy may be harvested, if early. Cotton bolls and chillies to be picked. Hoeing of sugar-cane. Harvesting of *kachu* and sweet-potatoes.

December.—*Aman* harvest. Sale of early English vegetables. Irrigation of sugar-cane, potatoes, cabbages &c. Hoeing round trees and other perennial plants. Picking of cotton, and chillies. Harvesting of yams, ginger, turmeric, ground-nut, radishes and *ól*, also sowing of *ól* for the August-September crop. Cutting of sugar-cane may commence, if early. *Kalái* and mustard may be harvested this month. *Champa note ság* may be sown this month or in January, if irrigation available. Sale of *palval* may commence, while sale of brinjals continues.

PART IV.

MANURES.

CHAPTER LXXXVI.

GENERAL SUMMARY.

MANURING is governed by what is called the Law of Minimum. Nitrogen alone will produce no crop, if Phosphoric acid, Potash, Lime &c. are absent. Similarly Phosphoric acid and Potash alone without Nitrogen &c. will produce no crop. If by adding 8 lbs. of N, 10 lbs. of Potash and 5 lbs. of Phosphoric acid, one gets 14 maunds of oats, by adding 8 lbs. of N. and only 5 lbs. of Potash and 2½ lbs. of Phosphoric acid, one would obtain only 7 maunds. The Law of Minimum holds good even for moisture, light and heat: a minimum proportion of moisture, light and heat are needed for the growth of every crop. This minimum requirement of food and other conditions of growth, is different for different crops; but crops have not been so minutely studied yet to enable one to give a tabular statement of minimum requirements for each variety of every crop. Chemical analysis may prove certain amounts of plant food present, even in an available form, which are theoretically sufficient for obtaining the maximum yield. But even in such cases, manuring has given good result. Chemical analysis also does not take into consideration the potentiality of a soil for accumulating nitrogen, due to the growth of microbes under proper conditions of moisture, porosity, heat and presence of lime. As much as 100 lbs. of nitrogen per acre may be accumulated from the air,

in this way, during the year, and particularly during the preparation of soil and growth of crop. The growing of leguminous crops in rotation is another inexpensive way in which land is enriched.

809. Notwithstanding the device of growing leguminous crops every now and again, continuous cropping without manure does result in the gradual deterioration of the soil. In some countries every crop is grown by the application of a manure. In these, the yield of crops instead of diminishing, in course of time, gradually increases. The application of *special* manures, time after time, though resulting in immediate beneficial effect, tends to impoverish the land in course of time. *General* manures being less soluble and supplying *all* the requisite nourishment are, therefore, preferable.

810. Manures are divided into 4 classes:—

(1) Phosphatic manures *e. g.* bone meal, bone ashes, dissolved bones, superphosphate of lime, apatite &c. This class of manures possesses the following special properties:—

(*a*) They tend to make the fruits and roots sweeter.

(*b*) They tend to increase the flowering and fruiting tendencies of plants and also increase the absolute yield of seed and roots.

(*c*) They make ripening of crops to take place earlier. Bone dust can be had of Messrs. Mackillican & Co. of 7 Church Lane, Calcutta for 2 rupees a maund, and powdered apatite from Messrs. Ewing & Co. of Calcutta for Rs. 3 a maund. Oil-cakes and ashes also contain large proportions of phosphates. Cowdung and horsedung ashes are specially rich in phosphates. The indirect method of manuring by feeding cattle liberally with oil-cake and utilising their excrements as manure is better than applying oil-cake direct as manure to the land. Once in 5 or 6 years every plot of land should be left fallow, and on it cattle should be tethered or hurdled in and given oil-cake to eat so that their excrements solid and liquid may enrich the soil. Liquid manure is better than solid manure.

(2) *Nitrogenous manures.*—The principal nitrogenous manures are, saltpetre, sulphate of ammonia, sodium nitrate, blood, flesh, hair, horns, hoofs and soot. The special value of this class of manures consists in their capacity for increasing the vegetative or leaf producing power of plants. Those crops that are valued for leaves only, such as cabbages, pot-herbs, mulberry, tobacco, *pan*, tea, are benefited by nitrogenous manures. For all other crops, except leguminous crops, the application of nitrogenous manures at an early period of growth after germination gives a good start. Saltpetre is specially beneficial for cereal crops. Application at the rate of one to two maunds per acre has been found to double the yield. Saltpetre should be used on fertile soils only or used in conjunction with phosphatic manure, as it makes the constituents of soil soluble and liable to be washed away. The best result is obtained by the application of phosphatic manure with saltpetre. Oil-cakes are general manures rich in phosphorus, nitrogen, potash, and lime. Bones containing about 23 % of phosphoric acid and 3·5 % of nitrogen may be regarded either as a general manure or a phosphatic manure. Being a general manure, it has no tendency to impoverish the soil by continuous use. Superphosphate of lime contains 40 or 50 % or more of P_2O_5 but hardly any N. Oil-cakes contain 5 to 6 % of nitrogen and 2 or 3 % of P_2O_5. Urine contains a larger portion of nitrogen than dung. Dessicated urine contains as much as 20 % nitrogen. Solid manure also, *e. g.* dung contains more N. than phosphoric acid, and may therefore be regarded as a nitrogenous manure, while it is also a general manure. A ton or about 27½ maunds of cowdung contains 5 to 7 seers of nitrogen and 2 to 4 seers of phosphoric acid and potash. Sulphate of Ammonia and nitrate of soda are quickly acting nitrogenous manures, but they leave the land comparatively poor after a crop has been raised by the application of one of them. Blood, flesh, bones, oil-cakes, solid or liquid excrements of animals and black

earth dug out of old tanks in renovating them, though not quick acting manures and though they may be all called nitrogenous manures, do more permanent good to the soil, as they contain all the ingredients the plant requires and as they have no special power of dissolving the soil and rendering its constituents too readily available as plant-food. Where leaf production is sought, the application of saltpetre should be resorted to without any hesitation. It should be noted, however, that the saltpetre should never be applied at the time of germination or brought in contact with leaves. It is to be mixed up with soil, or spinkled very much diluted with water, ashes or earth.

(3) Potash manures.

(*a*) Ashes of all kinds, especially ashes derived from soft parts of plants and from seeds, as for instance, cowdung ashes.

(*b*) Animal excreta, vegetable moulds, rotten leaves, tank earth, indigo refuse &c.

This class of manures is also helpful to certain vegetative functions *i.e*, to the production of leaves, deposition of starch, formation of roots and also to flowering and fruiting. A maund of cowdung contains about ½ seer of potash, ½ seer of nitrogen, ¼ seer of P_2O_5, if 20 maunds of cowdung are applied per *bigha*, the soil receives an addition of about 10 seers of N, 10 seers of K_2O and 5 seers of P_2O_5. A maund of oil-cake contains about 2½ seers of N, 1 seer of P_2O_5, and a little over of ½ seer of K_2O, in other words, oil-cakes are 5 times richer than cowdung in N, 4 times in P, and quite equal to cowdung as a potassic manure. As potash is more or less abundantly present in every soil, the application of 1 maund of oil-cake is equivalent to that of 4 or 5 mds. of cowdung; in other words, 4 or 5 mds. per *bigha* is an adequate application of oil-cake for all ordinary crops (*i.e.* rice, jute, &c.). Crops valued for their leaves or for pods are more benefited by the application of

ashes than oil-cakes. Crops valued for their pods though benefited by potassic manures are actually damaged by nitrogenous manures. Saltpetre, oil-cake, solid and liquid excrements of animals are therefore unsuitable for leguminous crops. Ashes contain as a rule 5 to 10 % of potash.

(4) *Calcareous manures.—e.g.* lime, shells of cockles and snails, *kankar*, gypsum, &c.

This class of manures is best suited for leguminous crops, their chief function being to make the other constituents of soils readily available. Like phosphorus and potash, lime also increases the flowering and fruiting tendencies of plants. Whenever therefore it is noticed that plants or trees are vigourous in producing leaves but backward or reluctant in putting forth flowers and fruits, the application of lime, ashes, and bones should be at once resorted to.

(5) *Salt.*—This is scarcely of any value as a manure except for certain special crops such as cabbages, beet, asparagus, cocoa-nut, etc. Impure salt and *Khari nimak* are better manures than pure salt, as they contain an admixture of saltpetre and sodium sulphate.

811. The practical advice of Lawes and Gilbert, the greatest agricultural chemists of England, should be always borne in mind in choosing special manures for special crops:—"Use phosphates for turnips and such like root-crops, potash for leguminous plants and active nitrogen for grain."

812. *Indirect manuring.*—Under this head may be included the following:—

(*a*) Feeding of cattle with oil-cake on fallow land.

(*b*) Growing of leguminous crops, for pulse and for fodder.

(*c*) Growing crops by irrigation but not too free irrigation.

(*d*) Cleaning of sewers, tanks, *jhils*, wells every two or three years, clearing them of all impurities including vege-

table and animal remains or growths and applying them as manure to fields.

(*e*) Gathering of weeds when they are in flower and pitting them as manure.

(*f*) Growing of large mulberry trees for sericulture and utilising the silk-worm droppings &c. as manure.

(*g*) Burning weeds and jungles and then cultivating the land. This should be done only on rich forest or hill tracts. It results in the acidity of the soil being corrected, insect and other pests destroyed, weeds being easily and effectually removed, ashes from burnt weeds getting mixed up with soil and thus adding to its fertility directly, and indirectly by the manurial constituents of the soil being rendered more soluble as plant-food.

(*h*) Cultivation of land as long before the sowing season as possible, except in the rainy season, when land should not be left tilled without a crop.

(*i*) Use of certain insecticidal and fungicidal substances that have a manurial value at sowing or transplanting time. These substances are castor-cake and rape-cake dust, soot, salt, ashes and lime.

813. *Economical manner of applying manure.*—In this matter the Chinese are the most proficient. Instead of applying the manure all over the land, they put it at the base of each plant.

814. *Covered pit.*—Every cultivator should have a covered pit for throwing in such refuse matter as sweepings of all kinds, weeds, hair, feathers, useless seeds and stones (like mango or lichi stones), bones, flesh, blood, shells, nails, ashes besides dung and urine. Over this pit should be sprinkled from time to time gypsum or sulphate of iron or copper. Mixed refuse of all kinds treated with lime or gypsum is called "compost." The addition of copper sulphate or sulphate of iron is recommended only when there is any sanitary need for it.

815. *Liquid manure.*—Urine gives better result when it is applied in the fresh state than when it is allowed to ferment. But being too rich it should be diluted with 10 or 20 times as much water, or applied before preparing the land for a crop. If it has to be stored for sometime before use, the addition of 1 part of sulphate of iron to, 2,000 parts of urine stored, is recommended, both for sanitary reasons, and for preventing fermentation.

CHAPTER LXXXVII.

EXHAUSTION, RECUPERATION AND ABSORPTION.

WHETHER cropping without sufficient manuring has been steadily exhausting Indian soils or not, has been usually answered by experts in undoubted affirmative. Professor Wallace of Edinburgh University, however, says, "Temporary fertility, the qualities possessed in virtue of some accumulation of material useful to plant, may be dissipated, but when this is gone, no system of cropping can reduce the land to a lower point. The greater portion of the land in India which is not newly broken in, annually produces its minimum yield. Where declining fertility has been recorded, it was no doubt due to loss of temporary fertility which had accumulated during a period of rest." Professor Wallace assumes as a practical agriculturist, without any proof, that the natural fertility of soils differs, and that this can never be exhausted. We can dismiss from consideration silica, iron, alumina, magnesia, soda, lime and even potash, as being abundantly present in every soil for thousands of crops. But the case is different with Phosphoric acid and Nitrogen. That soils may

become poor in these constituents and may be benefited by phosphatic and nitrogenous manures are well known facts. At the same time, it should be remembered that there are three natural methods of recuperation of Nitrogen which is the most important factor in determining fertility: (1) by rainfall, (2) by the return of the produce of the soil to the soil in the form of excrements, bodies of dead animals, &c., and (3) by the action of nitrifying bacteria especially in connection with the roots of leguminous crops. The total produce of food-grains in India has been estimated at eighty million tons and the total export of food-grains at 2,500,000 tons, *i.e.*, at about 3 per cent. So we may assume that 3 per cent. of the plant-food derived from the soil is absolutely lost to the country annually. There is also another loss due to burning of some of the excrements as fuel, the Nitrogenous portion of plant-food being entirely dispersed by burning. What the proportion of such excrements that are burnt, is, cannot be determined. Now one crop takes up per acre from the soil an average of about 15 lbs. of Nitrogen and $7\frac{1}{2}$ lbs. of P_2O_5. The grain is only exported and not the straw. So it is only 3 per cent. of an amount less than 15 lbs. of N. and $7\frac{1}{2}$ of P_2O_5, that is lost by export and we can add the N. which is lost by burning of cowdung to this. Most likely the total loss of N. per acre by cropping is less than 3 or 4 lbs. per annum and 3 or 4 lbs. of N. per annum comes down by rain alone in the form of nitric acid and ammonia. Then there is the accumulation by leguminous crops. So, Professor Wallace's opinion is probably correct as far as N. is concerned. The question of supply of P_2O_5 by conservation of bones or application of phosphatic manures is therefore of the utmost value for maintaining what Professor Wallace calls the permanent fertility of soils, as it is perhaps possible to exhaust the permanent fertility so far as P_2O_5 is concerned where the proportion of this constituent in the soil is only ·05 or less per cent.

816. In the case of phosphoric acid, on the other hand, we should take into consideration silt deposit, where this takes place and the settling of cosmic or meteoric dust. Permanent fertility cannot be exhausted in the case where there is annual movement of silt from higher to lower ground by the monsoon rainfall. For certain localities therefore Professor Wallace's remark that the permanent fertility can never be exhausted is correct. But that such minimum of fertility can be added to by manuring and more grain produced per acre, admits of no doubt. The fuller utilisation of excreta, human and animal, is of first consideration and then other sources of manure can also be considered.

817. European tea, indigo and coffee planters have begun to complain of exhaustion of soil. The tea now produced is weak, poor, thin and of inferior quality as compared to what was obtained 10 or 20 years ago and quite a crisis has arrived in the life of tea cultivation. Among the most useful suggestions that have been made in the matter of manuring tea-gardens, is the growing of castor-oil plants close to these gardens and utilizing the cake.

818. It has been said that chemical analysis is not a sufficient guide for judging the actual value of soils but only its potential value; in other words, that it does not give any idea of the amounts of plant-food existing in an available form, but only the total quantities of plant-food present. With regard to potash and phosphoric acid, however, this remark does not apply as an empirical method has been successfully applied by Dr. Bernard Dyer of London of finding out the quantities of P_2O_5 and K_2O existing in an available form for the immediate use of plants. With regard to nitrogen, however, no satisfactory method has yet been discovered of finding out the proportion of available nitrates &c. present in the soil. Indeed, it is difficult to find this out with reference to any soil, as nitrates are so easily washed out. At one time there may be as much as $\frac{1}{4}$ per cent. of available nitrates &c. in the soil,

but if the soil is left ploughed up and bare for a few days and if heavy rainfall takes place, the same soil may show less than $\frac{1}{20}$th per cent. of available nitrate. Loss by drainage may come up to as much as 80 or 100 lbs. of N. per acre, but this is not what ordinarily takes place even in lands swamped with water such as the rice fields of Bengal are. The chief protection against the loss of nitrates and indeed of all soluble plant-food is the generation of vegetable and animal life, visible and microscopic, at the beginning of the rainy season. When the rainy season actually commences, fields which are not under crops, have a luxuriant growth of weeds and minute vegetation and also of animals large and small. The animal and vegetable life growing rapidly in the soil throughout the rains prevent to a great extent the washing away of fertility. The question of loss of nitrate and other soluble food-materials by drainage is very complicated, but the loss is not so very great in the tropics owing to the rapid propagation of vegetable and animal life of all sorts which helps to convert soluble nitrates &c. into comparatively insoluble protoplasmic bodies.

819. *Absorptive power of soils.*—To understand how the utilization of phosphates, potash, lime and other food-materials by plants is governed, it is necessary to get an idea of what is called the absorptive power of soils. It is not altogether a chemical process. It is both physical and chemical. Bases and salts are partly absorbed by the soil as a whole and partly decomposed. Cut off the bottom of a large bottle and place the bottle vertically with its mouth downwards, the mouth being secured with a plug of cotton wool. Fill the bottle with clay loam slightly dampened with water. Then pour dilute ammonia water in small quantities until the liquid begins to drop from the lower end. It will be found that this liquid is little more than mere water. In this way, considerable quantities of ammonia are absorbed by clay. If you repeat the above experiment with K_2SO_4 solution instead of ammonia

water, the water percolating out will be found to contain only traces of K_2SO_4, but more of $CaSO_4$, $MgSO_4$ and Na_2SO_4. If you use $MgSO_4$, the water percolating out will be found to contain little $MgSO_4$ but more Na_2SO_4, $CaSO_4$ and K_2SO_4. If you use Na_2SO_4 the filtrate will contain little Na_2SO_4 but more of $MgSO_4$, $CaSO_4$ and K_2SO_4. If you use KNO_3 solution the filtrate will be found to contain little or no KNO_3 but more of Ca_2NO_3, Mg_2NO_3 and $NaNO_3$. In each of these cases the bases supplied are retained by the soil by chemical agents lurking in it, while lime, magnesia or some other base is removed with the acid radicle, if any. Ammonia water not containing an acid radicle, the water comes out pure, while in the other cases the sulphuric or nitric acid combines with the bases of the soil.

820. Now try similar experiments with phosphate of potash and silicate of potash. It will be found that both phosphoric acid and potash in the one case and silicic acid and potash in the other, are retained by the soil. Alkaline carbonates are also absorbed by the soil hardly without decomposition. Speaking generally, chlorides, nitrates and sulphates are decomposed, while silicates, carbonates and phosphates are absorbed without decomposition. Soil has also the power of absorbing minute quantities of chlorine, H_2SO_4 and HNO_3. In each case the absorptive power is limited, *i. e.*, after a time the filtrate or the water percolating out of the cotton wool end of the bottle will be found to contain the salt poured in without decomposition or absorption. Soils do not absorb all the bases with equal readiness. They have the greatest absorptive power for NH_3, then for K_2O, then for MgO, then for Na_2O and lastly for CaO. When the material for absorption is ready at hand the maximum degree of absorption is reached within a few hours, except in the case of phosphates. When there is phosphoric acid ready for absorption the maximum degree of absorption is reached after several days. Relatively

more is absorbed out of a dilute solution, though from a strong solution absolutely a larger quantity is absorbed The quantity of bases (and acid radicles in the case of phosphates, silicates and carbonates) absorbed depends on various conditions: (1) the relative masses of soil and the solution; (2) temperature,—less being absorbed in high temperature and (3) the state of the combination of the substance to be absorbed. For instance, more K_2O is absorbed when it is given to the soil in the form of phosphate than as chloride or nitrate. The bases absorbed are only slightly soluble in water, more soluble in water containing CO_2, and completely soluble in HCl. When a base has been absorbed, it may be partially or wholly removed by another base, *e. g.*, if a soil saturated with absorbed K_2O, is given a dose of Na_2SO_4 solution in the above described manner, part of the K_2O will be removed, (*i. e.* much more than if the soil had been washed only with water), and its place taken by Na_2O. If now the soil is washed with a solution of lime, more of the K_2O and part of the Na_2O will be washed out and their place taken by CaO. The absorptive power of soils is diminished or entirely destroyed by treatment with HCl or by ignition. A soil, the absorptive power of which is diminished or destroyed by either of these ways can get back its power if it is treated with Na_2Co_3 or $CaCo_3$. All soils have not equal absorptive power. Speaking generally the greater the absorptive power of the soil the greater is its fertility. All good soils decompose to a certain limit salts of potash, magnesia, soda and lime, in such a manner, that the bases, and the phosphoric, silicic and carbonic acids, if they are present, are retained in the soil, and nitric, hydrochloric and sulphuric acids become dissolved in the form of compounds of lime, soda, magnesia &c. taken from the soil, and then either taken up by roots of plants or washed away, or deposited in the dry weather as an incrustation or inflorescence on the surface. Though clay loams possess the power

of absorption in a very marked degree, absorptive power has been noticed even in compact rocks, such as basalt, shale, or marl zeolites.

821. Soils with double silicates have higher absorptive power. The hydrated double silicates in the soil resemble zeolites, which contain Ca, Mg, K and Na and are decomposed easily by HCl. Some of the natural double silicates of the soil have been actually identified as zeolites, and those containing such have the high absorptive power of zeolites. An artificial preparation of silicate of alumina and soda possesses an absorptive power resembling that of clay loams. The artificially prepared hydrated double silicate which shows the highest absorptive power, contains 46 per cent. of SiO_2, 26 per cent. of Al_2O_3, 16 per cent. of Na_2O and 12 per cent. of H_2O. When this artificially prepared double silicate is treated with a lime salt most of the Na_2O is replaced by CaO, and when it is afterwards treated with K_2O, CaO is partly replaced by K_2O. In the same way, MgO and NH_3 can be made to enter into the composition of this artificial mixture which may now be called soil. That natural soils contain similar double silicates to those of this artificially prepared soil, is rendered certain by the following facts :— (1) Soils after treatment with HCl yield to a solution of Na_2CO_3 much larger quantity of soluble SiO_2 than before treatment with HCl, and such soils generally have a high absorptive power. (2) Soils treated with HCl which lose their absorptive power regain this power on addition of Na_2CO_3 or $CaCO_3$ which enables the precipitated SiO_2 to reform hydrated silicates. (3) Hydrates of Fe and Al have the power of absorbing small quantities of NH_3, K_2O &c., when presented as hydrates, carbonates, or phosphates ; but they have very little power of absorbing bases when presented in the form of chlorides, sulphates, or nitrates. They have the power of fixing P_2O_5 and also absorbing small quantities of HCl and H_2SO_4 fixing them as highly basic compounds. (4) Hydrated Silicic

acid has an absorptive power for free bases or carbonates. (5) Humus also has the power of absorbing bases when they are in free state, or as carbonates or silicates. When P_2O_5 is presented in a soluble form as $CaH_4P_2O_8$ (Super phosphate of lime) it first acts on the $CaCO_3$ of soil to form $Ca_2H_2P_2O_8$ (Dicalcium Phosphate) and afterwards $Ca_3P_2O_8$ (Tricalcium Phosphate); possibly some $Mg_2P_2O_7$ also is formed. These combining with the iron and alumina of the soil become fixed as Phosphates of iron and alumina. The reactions that take place may be expressed by the following formulæ:—

(1) $3CaH_4P_2O_8 + 2Fe_2O_3 = 2Fe_2P_2O_8 + Ca_3P_2O_8 + 6H_2O$.

(2) $3CaH_4P_2O_8 + 2Al_2O_3 = 2Al_2P_2O_8 + Ca_3P_2O_8 + 6H_2O$.

822. The absorption of P_2O_5 is more rapid in calcareous soils than in clays or sands. Clays and sands go on absorbing P_2O_5 for several days. One of the functions of $CaCO_3$ in soils is to supply lime with which acids of certain salts may combine, so as to enable the bases to be absorbed. The Calcium carbonate of the soil naturally present or added as manure, helps to keep up proper equilibrium between bases of the compound silicates.

823. The three kinds of absorption may be shortly illustrated thus:—

(1) *Physical absorption, e.g.*, when colouring organic matter is removed from buffalo-dung (dung of buffaloes fed on mango leaves), litter &c., and absorbed by the soil.

(2) *Absorption without exchange of bases*, as in the case of hydrates, carbonates, phosphates and silicates. Hydrates of Fe and Al and humus take an active part in this absorption.

(3) *Absorption with exchange of bases* in which the hydrated compound silicates are the active agents. For ordinary fertile soils this kind of absorption plays the most important part. Those ash constituents of plants which are most valuable and least abundant in the soil are those which are fixed in large quantities; *e. g.*, P_2O_5 and K_2O. These when liberated in the soil by the action of weathering of

rocks or soil particles, are immediately fixed by this absorptive power. Those saline matters which are easily washed away, *e. g.*, Chlorides, Sulphates and Nitrates, are (with the exception of nitrates), either required by plants in very insignificant quantities, or are abundantly present in the soil, or supplied to it without human aid.

CHAPTER LXXXVIII.

NITROGENOUS MANURES.

OF the four principal manurial constituents,—nitrogen, phosphorus, potassium and calcium,—nitrogen is the most important, and, on the whole, it may be said, the richer a substance is in nitrogen the greater is its value as a manure. Green plants are not able to make any use of the free nitrogen of the air, but fungi can make some use of nitrogen in this form. Minute fungi, called Bacteria, having a tendency to accumulate nitrogenous organic compounds at the roots of plants, chiefly of the leguminous order, these plants derive benefit from the free N of the air through the help of these bacteria. As nitrites also, plants are not able to make use of N. The nitrates contained in irrigation water coming in contact with sewage, become reduced to nitrites, in which form the N is of no use to plants. Irrigation with sewage water is therefore not a very effective means of applying nitrogenous manure to land. Nitrogen is absorbed by plants chiefly in the form of nitrates, ammonia salts, urea, uric acid, and hippuric acid. Nitrates occur in nature as saltpetre (KNO_3), Chili saltpetre ($Na\ NO_3$) and also as saline inflorescence on walls, which is calcium nitrate ($Ca\ 2NO_3$). Ammo-

nium nitrate also occurs in air and in rain water. Saltpetre and Chili saltpetre or sodium nitrate are largely used for manure. Of ammonium salts, the substance largely used for manure is ammonium sulphate which is manufactured out of gas-liquor, and is therefore a bye-product of gas-works. The crude gas-liquor diluted with water is also used for application on wheat and other cereal crops. Urea is also made use of directly by the roots of plants, and fermentation of urine which results in the generation of volatile ammonia salts, should therefore be prevented, either by applying urine fresh on lands, diluted with water, or storing it in tanks by the addition of an antiseptic substance such as Ferrous sulphate for future use but in an unfermented state.

825. *Nitrates.*—In connection with the question of recuperation of nitrogen in the soil, the nitrifying agency of bacteria is to be considered the most important. Loss by drainage is generally entirely made up by this natural recuperation. In fact, while the expenditure of N. per acre by cropping is only about 15 lbs., loss by drainage under an injudicious treatment may come up to as much as 80 or 100 lbs. per acre, but nitrifying bacteria have been also known to accumulate 80 or 100 lbs. of N. per acre. On the one hand, a free and moist soil is helpful to nitrification, while on the other, such soil is also liable to loss by drainage in wet weather. A free and open soil kept moist but at the same time protected from rain is therefore most helpful to the generation of nitrates. The presence of some organic matter in the soil is also essential. These conditions naturally prevail in village sites, and old homesteads dug up and used as manure are known to give good results. But artificial nitre-beds under shade may be formed on every farm, and the earth regularly used as manure. Further refined and purified, this nitrous earth, or *lona mati*, so extensively used as manure in the N.-W. Provinces and parts of Bihar, yields the saltpetre of commerce.

826. *Saltpetre is manufactured* largely in Bihar and to a certain extent in several districts of the N.-W. Provinces, the Punjab, Bombay, Madras and Burma. More than two-thirds of the saltpetre exported from Calcutta comes from Tirhut, Saran and Champaran. The climate best suited for the production of nitre is where dry weather follows the rains and thus by evaporation allows the salt to effloresce on the surface. Presence of carbonate of lime in abundance is helpful to the generation of nitre and this accounts for the district of Tirhut being so fruitful in the production of nitre, for almost half of its soil is calcareous. The manufacture in Bihar is in the hands of a caste called the Nuniahs, who revel in old village sites and mud walls. They make piles of loose earth after the rains are over and build mud walls round them that the precious stuff may not be washed away. This earth is obtained by scraping off an inch or two of the bed chosen and made into conical heaps 2 to 4 ft. high. By March or April when a large number of these heaps have been collected, the processes of solution and filtration begin. The best temperature for nitrification is 98° F. and if this and moisture can be given artificially in presence of lime and organic matter, nitre-beds and heaps should give the best results. *Kalsies* are placed on tripods, each *kalsi* having a hole at its bottom. A layer of straw is put at the bottom, over it ashes from indigo refuse, and then the vessel is nearly filled with the saline earth, in a loose manner. Under each *kalsi* filled with saline earth is placed an empty *kalsi* and above it one filled with water having an orifice at the bottom in the manner in which an ordinary *kalsi* filter is arranged. A series of these stands are erected side by side, and the liquid from the bottom *kalsies* is removed from time to time and boiled until the liquor comes out so free from salt that it is not worth boiling. The liquor obtained contains 2 to 5 % of saltpetre. Oval iron pans from 1 to 2 ft. in diameter and 6 to 9 inches in depth are used for boiling

the liquor. The diminishing liquid is from time to time replenished by fresh supplies. The impurities that rise are carefully skimmed off. On attaining a certain degree of concentration the impure saltpetre is copiously precipitated. This impure precipitate is scooped out from the bottom of the pan at intervals and heaped by the side of the boiler. After 30 to 36 hours, of continuous labour 8 to 16 lbs. of crude saltpetre are made ; the larger pans yielding up to 30 lbs. Solar heat is also used for evaporating the liquor. This crude saltpetre is exported to Europe and refined there. The principal impurities are Chlorides of Potassium and Sodium. Weight for weight, sodium nitrate is a richer manure than potassium nitrate in as much as it contains 7 per cent. more nitric acid. In the manufacture of gunpowder, however, potassium nitrate is in use, but for the manufacture of nitric acid, sodium nitrate. In India, potassium nitrate being much cheaper, it is the best nitrogenous manure to use, the potassium also being a valuable plant-food.

827. Nitrogen is absorbed by plants more readily in the form of nitrate than in any other form. In water-culture experiments nitrates are relied upon as the best source of nitrogen. Ammonia salts are less certain. Nitrates chiefly promote the growth of leaves and impart to them a rich green colour. In Peru, crude nitrate of soda is found incrusting the soil of a desert. Hence this article rather than saltpetre is chiefly used for manurial purpose in America and Europe. Scrapings from *pucca* walls or damp and dirty limestone buildings are rich in nitrate of lime which is also a good manure.

828. Saltpetre, Chili-saltpetre or sodium nitrate and calcium nitrate should be applied as manure mixed and diluted with some other substance such as water, loam or dung, at the rate of 100 to 150 lbs. per acre, mixed with 3 or 4 times as much dung or 10 times as much loam or water. The application should be only as top dressing when the plants

are 6 to 9 inches high, as germination and growing of young seedlings are hindered by the application. It is only in showery weather that it proves highly beneficial. It is therefore applicable to early *Bhadai* crops or early *rabi* crops. Grain crops are chiefly benefited, also those which are valued for their leaves, such as pot-herbs (*ságs*), cabbages, mulberry, &c. Onions, table vegetables and root-crops generally are also benefited by nitrates. Leguminous crops are actually injured by the application.

829. Each farmer can easily have his own covered and enclosed *nitre-bed* as a perpetual source of manure for his fields. It is important to secure a uniform temperature of about 98° F. Below 40° or 45° F. and above 130° F. nitrification ceases. The earth should be kept loose. There should be enough of moisture, lime and organic matter in it, but not too much of the first two. Warington could not ordinarily discover nitrifying Bacteria below a depth of 18″ and the looseness of soil in the nitre-bed need not therefore extend beyond 18″. Darkness also favours nitrification. This is one reason why manures should be kept in dark cellars and sheds. Compost heaps should be also kept under trees or sheds. Salt, coal-tar, spent lime of gas works, ferrous sulphate and disinfectants or germicides generally, retard the process of nitrification. Rapid putrefaction also hinders nitrification, and it is therefore necessary that manure heaps should remain sweet. A wet and puddly pen or cow house is not so suitable for the process of nitrification as a stall in which the dung is spread about and kept moderately warm and only occasionally moistened with urine. The lime used for nitre-beds should never be in the form of caustic lime which sets free ammonia and hinders nitrification, but in the form of carbonate. Warington has pointed out that if Gypsum is mixed with strong solutions of urine so that the carbonate of ammonia be converted to sulphate and the excessive alkalinity of the

liquid annulled, they could be nitrified more easily. Excessive alkalinity is inimical to the process of nitrification.

830. The practical lessons to be deduced from these principles are :—(1) Cattle should be fed in stalls where the manure should rot and be trodden upon. (2) The urine should be removed fresh and used separately as manure mixed with ashes and water. (3) If no provision is made for removing the urine, gypsum should be freely used in the stall. (4) Lime (slaked) should be occasionally spread in the stall. (5) The floor of the stall should be about 18 inches deeper than the surrounding level of the land. (6) Straw should be freely used for litter as it leaves openings for air to act on the manure. In other words, cowdung and litter may be utilized the basis for nitre-beds.

831. Nitrates are partially de-oxidized in swampy rice fields where the process of reduction occurs resulting in the formation of marsh gas. Even in soils rich in humus, nitrates are easily destroyed in the absence of O, quickly in high temperature and slowly in low temperatures. The nitrates are reduced and free N. gas escapes.

832. Nitrates in soils are probably chiefly derived from oxidation of ammonium compounds, resulting from organic matter coming in contact with lime ; also from various organic nitrogen compounds. It is not a purely chemical process which can be represented by chemical formulæ. In the laboratory, of course, nitrates could be evolved by treating nitrogen compounds with strong oxidizing agent *e. g.*, when caustic ammonia is boiled with potassium permanganate, or subjected to the action of peroxide of hydrogen. But in the soil the intervention of bacteria is the determining agent in the formation of nitrates ; but how these bacteria work is not yet known. That they live on nitrogenized organic matters and on ammonia compounds is known, and also that they give rise to nitrates.

833. *Urine* does not nitrify unless it has been diluted with water and mixed up with a great deal of earth. Very

dilute solutions of carbonate of potash, carbonate of soda and carborate of ammonia favour nitrification, but if the solutions are more concentrated than $\frac{2}{1,000}$ or $\frac{3}{1,000}$ they check the action of the ferment. If chloroform, CS_2, or Phenol is passed through soil, nitrification is arrested, owing to the death of the organisms; continual drying of soils at 100°C also prevents nitrification. When urine of animals is allowed to ferment, in considerable quantities, an undue proportion of ammonium carbonate is evolved and nitrification is checked. The popular belief that urine is injurious to land and that it burns up plants is therefore correct, though diluted it is such a valuable manure. In recommending the use of urine to cultivators the necessary caution should be always given. The nitric ferments find a fit soil in well-rotted manure which is not too wet. More than three-fourths of the value of dung depends upon the N. it contains.

834. The quantity of saltpetre annually exported from India is nearly 600,000 mnds. valued at over 40 lakhs of rupees. Most of this goes to Great Britain and the U. S. A. for the manufacture of gunpowder. It is more satisfactory to use this manure in a comparatively pure form (say, of 5 to 6 per cent. refraction, which costs in Calcutta about Rs. 5-8 to Rs. 6 per maund), than crude saltpetre which may contain 30 to 50 per cent. of foreign matter.

835. Notwithstanding the potentiality of soils for accumulating nitrates under specially favourable circumstances, the application of manures to soils has for its chief object addition of N. in an available form. In estimating the value of manures in a practical manner, NH_3, P_2O_5 and K_2O may be valued at *6as.*, *3as.* and *2as.* a lb. respectively. NH_3 is valued in England even at *8d.* a lb. Indian soils being particularly poor in N, and N being the most valuable plant-food, the proportions of N in various substances that are or can be used to enrich the soil, should be carefully studied.

836. *Farm-yard manure.*—The most easily available manure which is used for bringing N directly and indirectly into the soil is farm-yard manure. It consists of solid and liquid excrements and litter. It varies very much in composition. The conditions that determine the variation of composition are:—(1) age; (2) condition of the animal, whether lean or fat; (3) the species; (4) food; (5) temperature; (6) accommodation generally; (7) quantity and kind of litter used, and (8) management during accumulation and its after treatment.

837. During the passage of food through the alimentary canal of an animal, a large portion of the C and some of the H are lost by the processes of respiratien and evaporation, as CO_2 and H_2O. Nearly the whole of the N and the mineral matter are got back either in the solid or the liquid excrements. This is the case chiefly with adult and fattening animals. In the case of young animals and milking cows, the N excreted is much less. A little more than half the quantity of N taken in as food is given off in urine, which shows what a valuable nitrogenous manure urine is. The remaining half (or less) is partly voided with the solid excrement and partly stored up in the body of the animal. The N in urine occurs in the forms of Urea, Uric acid, Hippuric acid and Guanin.

838. The following table compiled from Johnston and Cameron's Elements of Agricultural Chemistry and Geology gives an idea of the composition of dung and urine of the various classes of farm animals in 1,000 parts:—

	Cow		Horse		Sheep		Pig	
	Dung.	Urine.	Dung.	Urine.	Dung.	Urine.	Dung.	Urine.
Water	860	915	750	900	640	950	760	976
N	3·6	9	6	11	6	8	7	3
P_2O_5	3	...	4	...	5	...	5	1·2
$K_2O + Na_2O$	2·2	16	3·5	14	3	8	6·5	2

839. Pig's urine and human urine are very similar in composition, especially in the high percentage of P_2O_5. Sheep's urine is the most concentated, then horse-urine, then the urine of ox and last of all pig and human urine. Cow-dung contains the largest proportion of water and is poorest in N of all the dungs. Horse-dung is drier and richer. Sheep's dung is the richest. Bird's dung and insect droppings are still richer in N, K_2O and P_2O_5. In order of value, insect droppings come first, then bird's dung and bat's dung, then sheep's dung and goat's dung, then horse's dung, pig's dung and human dung, and last of all dung of oxen and buffaloes. The principal differences in composition between dung and urine, besides the difference in the proportion of water, are :—(1) Urine is richer in N (except in the case of pig-urine) and in alkaline salts, (K_2O and Na_2O), while dung is richer in the earthy salts (Ca and Mg) and phosphates. (2) S_1O_2 is abundantly present in dung of animals chiefly because they eat a lot of earth with their food.

840. As the watery portion of urine and dung evaporates, urine gets richer and richer in N than dung, over 90 % of urine being water while dung contains 70 to 75 % of moisture. In allowing urine to get evaporated and concentrated, fermentation must be kept in check by adopting a quick method of evaporation, or by using an antiseptic substance.

841. Adult animals void a larger amount of nutritive matter than growing animals or animals in milk. The latter use up a good deal of phosphates, N and mineral salts required for the formation of bones, blood, and muscles, or milk. Pregnant animals and lean animals also absorb a good deal of nutriment and their excrements are poorer than those of fat animals.

842. Animals poorly fed (only on straw and ripe grass) yield poor manure. Animals fed on carrots, oats, pulses, chaff, bran, fresh green herbage and specially oil-cake, yield richer manure.

843. Buck-wheat straw used as litter adds to the value of the manure, and so does the straw of leguminous crops. The manurial value of cereal straws used as litter mainly depends on the proportion of N they contain. Dried ferns, rushes, and young leaves of all kinds used as litter have a special value as litter, as they contain a very high proportion of K_2O. The return of the straw in some form or other to the land is very essential, as straw contains ·5% of N, 1% of K_2O and ·3% of P_2O_5, and as an acre of land yields about 2,000 lbs. of rice straw per annum, the restoration of the straw is a great matter considering that the total quantity of N, P_2O_5 and K_2O taken out by a crop of rice (grain and straw) is about 10 lbs., 5 lbs. and 5 lbs. respectively. Practically no bedding material or litter is used in India for the comfort of cattle. In the Cawnpore Experimental Farm, a system of scattering dry earth on the floor of the cattle-stall, of removing it daily and drying it in the sun and using it again for scattering in the floor, has been introduced. This, no doubt, makes the *urine-earth* get gradually more and more concentrated in N, until as much as 1% of N accumulates when the earth is used as a nitrogenous manure. But the extreme alkalinty of the earth and the exposure to sun-light both go against nitrification. Nitrification, however, proceeds after this urine-earth has been used as manure. The use of dried leaves, or straw, or megass (*i. e.* crushed sugar-cane), for litter is advisable, also the feeding of cattle in covered stalls the floor of which should be about 18″ below the level of the surrounding ground. The accumulation of dung and urine and litter may go on until the manure reaches the level of the ground, when it can be removed to the pit or applied to fields. Gypsum should be scattered on the manure every now and again, if this system is adopted, to prevent formation of $(NH_4)_2\,CO_3$. Gypsum is also a mild antiseptic. The system of converting urine into urine-earth by drying it in the sun may be also adopted. The stall-fed manure which gives such good result in England

has been found to give good result in the Nagpur experimental farm also, and this system therefore is to be preferred. Indian cattle dung and urine (specially the latter) are not poorer than English cattle dung and urine, as the following results of analyses given by Dr. Voelcker will show:

	Cattle Dung.		Cattle Urine.	
	English farm yd.	Indian dung-cake	English.	Indian.
Moisture ...	66·17%	7·22%	91·50%	90·62%
*Non-volatile organic matter ...	28·24 „	65·32 „	7·00 „	7·64 „
†Mineral matter (ash) ...	5·59 „	27·46 „	1·50 „	1·74 „
	100·00	100·00	100·00	100·00
*Containing Nitrogen ...	·65%	1·48%	·90%	1·168%
†Containing				
Lime ...	1·35 „	1·96 „		·08 „
Magnesia ...	·15 „	——		·57 „
Potash ...	·67 „	·63 „		·643 „
Soda ...	·08 „	trace		
Phosphoric acid ...	·31 „	·54 „		·02 „
				·022 „

844. In 1 ton of farmyard manure there are 9 to 15 lbs. of N, 4 to 10 lbs. of P_2O_5 and 5 to 13 lbs. of K_2O. Manure made in boxes contains twice as much nitrogen (18 to 30 lbs. per ton). Rotten dung is more soluble and is a better manure than fresh dung, but it contains little free NH_3 which is combined with vegetable acids. During fermentation dung loses H_2O, CO_2, CH_4, H and N which are evolved in the process and thus it becomes more concentrated. Very little NH_3 is lost unless it is allowed to wash away. Dung which is not pitted but kept spread out loses two-thirds of its N; in pits or heaps, only a third of the nitrogen is lost, but when the pit is covered it loses only 10 per cent. of N.

845. Experiments conducted in the different Government

Farms in India have led to the conclusion that the application of about 6 tons of cowdung per acre, results in an increased outturn of 300 to 400 lbs. of wheat (Cawnpore and Dumraon). The figures for Nagpur give an increase of 200 to 300 lbs. In the case of maize the average increase at Cawnpore has been 400 to 500 lbs. per acre.

846. *Poudrette*, or night-soil manure pitted with ashes and town refuse, naturally varies very much in composition. The poudrette formed in deep municipal trenches gives rise to offensive smell, and the Meagher system of utilising night-soil by depositing it on beds and covering these with 3″ of soil, is less offensive, as the decomposition in the latter case especially in the dry weather is very rapid. The poudrette made by drying only, on the continent of Europe, contains about 25 per cent. of moisture, 3 per cent. of N, 3 per cent. of Phosphoric acid and 1½ per cent. of Potash. Mixed with $CaSo_4$, earth, &c., the poudrette is less valuable as nitrogenous manure containing only 2 per cent. of N or less. The poudrette made at Poona was found to contain about 1 per cent. of N and ¼ to 1½ per cent. of P_2O_5. The poudrette made at Cawnpore was found to contain ·4 to ·7 per cent. of N. The increased outturn from poudrette at Cawnpore from the application of 6 tons per acre has been 500 to 1000 lbs. of maize and 400 to 600 lbs. of wheat per acre in excess of the unmanured plots. Weight for weight poudrette has been found a better manure than cowdung. At the Allahabad Grass Farm the amount of night soil applied per acre (on the Meagher system) is 168 tons per acre once in 10 years. The weight of green grass obtained at this Farm varies from 10 to 30 tons per acre per annum which is equivalent to 3 to 10 tons of hay. A more extended use of night-soil and urine for manure is highly desirable. It is in this respect that the Chinese system of agriculture is in advance of the Indian. *Town sweepings* are less valuable as manure, as they contain about ·3 or ·4 per cent. of N, but as it has

no offensive odour it should be readily used for manure. At Poona it is used for sugar-cane and at Allahabad for grass land with very satisfactory result. The sullage water of town drains which is usually run into the nearest river is also a valuable manure. Mr. Wyer, a Collector of Meerut, utilised his small farm for the purpose of illustrating its value to cultivators. Two irrigations with it doubled the outturn of cotton, maize, juar, and oats over that obtained with well water. There is indeed a large supply of manure in cities and mofussil towns which is usually allowed to go to waste. Conservancy arrangements may be made a source of profit if municipalities are properly conducted.

847. The value of river, canal and tank *silt* as manure is still more difficult to ascertain than the value of dung, urine or town refuse. Silt is a very important source of plant-food and recuperation of land. In eastern Bengal, large tracts of country depend on silt only for manure. The results of analyses made by Dr. Leather with the Upper Eastern Jumna Canal silt show that the silt deposit during the monsoon period is more than sufficient for the rice crop (32 lbs. of N. and 41 lbs. of P_2O_5 per acre having been accounted for from this source), while during the cold weather when the canal water is clear, the amounts of N. and P_2O_5 supplied by silt deposit are very insignificant (only $\frac{1}{2}$ a lb. of N and 1 lb. of P_2O_5 per acre). All silts, however, are not valuable. Sandy silt may be deposited on good soil and cause damage to the soil.

848. *Humus* or vegetable refuse in soil is of little direct use to plant. Some experimenters have even opined that humus is poisonous to plants; but the balance of evidence shows that indirectly it is a valuable source of plant-food and to the lower forms of vegetable life it is a direct source of food. Ammonia and nitrates, which are the principal forms in which N is taken up by plants, are present only in very minute proportions, the greater proportion of N remaining in

the soil in a non-mineralised and non-available form. Peat contains 1 to 4 per cent. (usually about 2 per cent.) of N. The usual proportion of N in soils is from ·01 to ·5 per cent. when a soil contains more than ·5 per cent. of N it should be considered very rich in this important constituent. Humus boiled with alkalies gives off N in the form of NH_3. The nitrogen in humus exists in various unavailable combinations, and it is only slowly rendered available by the action of alkalies, by fermentation. Part of the N is lost as free N in course of fermentation, but the greater portion enters into organic combination which are more or less insoluble and undecomposeable. The albuminoids of the vegetable refuse are decomposed into two amides (Leusine and Tyrosine) which are allied to gelatine. In fact gelatine is an amide carbohydrate. If sugar or dextrine is heated at a temperature of 350°C in contact with NH_3 vapour, a substance containing about 16 per cent. of N is formed, which resembles natural gelatine and gives off NH_3 when heated with alkalies. Albuminoids, amides, and other nitrogenous organic compounds occurring in the humus of soils are probably incapable of affording nourishment to plants. Boussingault performed some experiments to show that if N is supplied to soils in organic forms only, plants do not grow well; but supplied in mineral forms and especially as nitrates, they do well. He also showed that nitrates are slowly formed out of the organic compounds by natural oxidation in the soil. Nitrates are undoubtedly the most valuable of all plant-foods.

849. Ammonia, urea, uric acid, hippuric acid and guanin (which occur in urine) are also assimilated directly by plants. Urea is of equal value to salts of ammonia applied in equivalent quantities. Though the constituents of urine just mentioned are capable of direct assimilation by plants and are so taken up in part by plants, they are actually readily transformed first into ammonia and then into nitrates. It is curious, that urea

$\left(CO\begin{matrix}NH_2\\NH_2\end{matrix}\right)$ and ammonium cyanate (NH_4CNO) which are metameric and have the same composition (but not constitution) as also Ammonium Sulpho or Thio-Cyanate (NH_4CNS) and Sulph-urea $\left(CS\begin{matrix}NH_2\\NH_2\end{matrix}\right)$, have totally different values as plant-foods. Ammonium Cyanate and Am-Sulpho Cyanate are poisonous to plants, while urea and sulph-urea are valuable plant-foods.

850. *Ammonia.*—The soil under ordinary circumstances absorb and condense minute quantities of NH_3 from the atmosphere, but the NH_3 of the soil is also being continually diffused into the air. If a soil contains a good deal of NH_3 and is in a moist state, it is rich in plant-food, but on drying such soil readily parts with its NH_3. On moistening this soil again and drying it, more NH_3 is given out and so on. The constituents of soil which have the greatest attraction for NH_3 are clay, ferric hydrate and aluminum hydrate. With acids of the humus group and with compound silicates, NH_3 forms compounds which are very sparingly soluble. NH_3 escapes in the air probably as $(NH_4)_2Co_3$. If $CaSo_4$ and $(NH_4)_2$ Co_3 are mixed together the mixture smells strongly of NH_3, but if the mixture be thoroughly moistened with water the odour of NH_3 is no longer perceived, Am-sulphate and $CaCo_3$ being formed. If the mixture is dried $(NH_4)_2$-Co_3 is again given off and $CaSO_4$ is formed. $CaSO_4$ is therefore called a fixer of ammonia but it is only in the damp state that it is a fixer. KCl, Kainit, clay and peat are also fixers of Ammonia. Of these, gypsum may be used in dung-heaps and stables, but Kainit is the best substance to use, then peat, then clay, and then gypsum. It is difficult to estimate the amount of NH_3 in soil and manure. It is being continually changed into HNO_3 and part of it also is constantly being dispersed into air. If a quantity of soil is boiled with caustic alkali, not only is the NH_3 actually present obtained in the distillate, but also an addi-

tional quantity liberated from the organic matter present. If MgO is used instead of K_2O, much smaller quantities of NH_3 are obtained. The actual proportion of NH_3 in soil is only about ·0005 per cent. There is a constant interchange of NH_3 between water, air and soil and the sea appears to act as the final reservoir for much of the NH_3 washed away by drainage and percolation. But the sea also gives off NH_3 to air, more in the hot weather than in the cold. The air of hot countries and of towns contains a larger proportion of NH_3. The subsoil contains less NH_3 than the surface soil and there is no NH_3 below a depth of about 6 ft.

851. *Nitric acid* is formed in the air by electricity and in some cases by the action of O_3 and then brought down by rain and dew, and other meteoric waters, nearly always combined with NH_3 as Ammonium nitrate. Priestley first noticed the formation of HNO_3 in the atmosphere and Liebeg found it in rain water. Nitrates and Nitrites are formed in the soil also and in manure heaps and their formation and removal by plants and drainage are questions of very great importance to agricultural science. Some chemists are of opinion that nitrates are formed from the free N of air by the intervention of soil only, but there is no certain proof of this; but that they are formed by the invention of bacteria has been proved. Nitrous and Nitric anhydrides are formed by electricity or ozone. NH_3 is also converted into HNO_3 by the same agency, but not free N of the air. NH_3 is to a certain extent fixed by soils, but Nitrates are very soluble and they are washed away chiefly in combination with lime as Ca_2NO_3. Soils containing much Ferric hydrate ($2Fe_2O_3\ 3H_2O$) are better able to retain nitrates as basic Ferric nitrate. Soils containing much organic matter to which air has not free access have their nitric acid reduced to NH_3, partly to free N, and Nitrous oxide. In the last two forms N is useless to vegetation. This is one reason why humus soils should be kept well cultivated whether

there are crops on them or not. When a soil is in good condition as much as 80 lbs. of N are converted into nitrates (Sodium, Potassium and Calcium nitrates chiefly) per acre, to a depth of 27 inches, the largest quantity being formed in the top 9 inches. The ratio has been found in England between the first 9 inches, the next 9 inches and the last 9 inches to be 100 : 60 : 30. Crop residues being easily nitrifiable, those crops which leave behind a large quantity of organic matter go to improve soils irrespective of any consideration as regards root-nodules &c. Again, old nitrogenous organic matter in the soil nitrifies much more slowly than recent organic matters. Restoring the straw of a newly grown crop is therefore very essential in forming nitrates.

852. NH_3 is *absorbed by plants* both by roots and by leaves, HNO_3 only by roots. The darkness of colour of leaves is intensified with NH_3 which also stimulates the growth of leaves and stems at the expense of flowers and fruits. 3 to 10 lbs. of NH_3 is found deposited by rain water per acre per annum. Nitric acid is also present in rain water, dew, fog, snow and other meteoric water. Nitrous oxide (N_2O_3) occurs as well as Nitric oxide (N_2O_5). But ozone and H_2O_2 convert the N_2O_3 into N_2O_5. From 3 to 7 lbs. of N_2O_5 (including the convetred N_2O_3) have been found deposited per acre per annum. The total amount of combined N useful for plant life, deposited per acre per annum as NH_3, N_2O_5, organic dust &c., has been found to be on the average $4\frac{1}{2}$ lbs. at the Rothamsted Experimental Farm in England. Continual calculations give over 10 lbs.

853. The amount of N *washed out* from soil varies under varied conditions, (1) according to the severity of rainfall, (2) according to the texture of soil and the nature of cultivation, (3) according to the slope, (4) according to its absorptive power and chemical composition and (5) according to the nature of the crop growing on the soil, or whether there is

any crop or not. One inch of rain-water passing out in drain and containing only 10 parts of N in 1 million parts of water would take away 2¼ lbs. of N per acre valued at 1*s.* 6*d.* in England (*i. e.* 8*d.* per lb.).

854. Plants contain N chiefly in the form of *albuminoids*. These have very complex composition, consisting of C, H, O, N and minute proportions of S and P. Vegetable and animal albuminoids resemble each other closely in composition. Ordinarily albuminoids are formed in plants and they undergo very little change in animals consuming these plants. 14·7 to to 18·4 per cent. of the constituents of albuminoids are N, and the average is taken to be 16 per cent. In estimating the proportion of albuminoids in a plant, the estimated N is multiplied by 6·25 ($16 \times 6{\cdot}25 = 100$). Some albuminoids are soluble and some insoluble. In determining, however, the albuminoids in vegetable substances, it is not sufficient to estimate the total N, as other nitrogenous substances, such as asperegin, occur in plants. The carbolic acid process of determination of albuminoids is the best. Warm the substance with a solution of Phenol and metaphosphoric acid which coagulates albumins and renders them insoluble. Wash the precipitate with water containing phenol. Then estimate the N in the precipitate in the usual way. This gives the N in the albuminoids. The N thus estimated multiplied by 6·25 gives the true albuminoids. Turnips contain ½ to 1 per cent. of albuminoids; potatoes 1 to 2 per cent.; cereals about 12 per cent.; rice containing less than 7 per cent., leguminous seeds 24 per cent. Albuminoids are the most nutritious food constituents of plants and the most important manurial constituent of humus. N as well as ash are relatively in larger quantities in young plants. With increase in age C, H, and O are assimilated by plants in larger and larger proportion and carbohydrates are therefore manufactured more towards the end of their growth and nitrogenous matter more towards the commencement.

855. *Green-soiling* or *green-manuring*, *i. e.*, ploughing in of fresh vegetable manure, not only supplies nitrifiable plant-food, but also mineral matters; and it alters the physical character of the soil, tending to make light soils heavier and heavy soils lighter. By decomposition of vegetable and animal manures (the latter decomposing more readily than the former) CO_2 is evolved which indirectly helps the growth of crops by making soil particles soluble. The easiest way of supplying organic matter to soil as manure is to grow some rapidly growing and tall leguminous crop in the rainy season and to plough it in when it is in flower. This not only draws up valuable materials from the subsoil to the surface soil, but also adds to the stock of nitrates in the soil which are not washed away so readily by rain as when the land is bare or contains some short or thinly growing crop. Of all Bengal plants suitable for green soiling *dhaincha* (Sesbania aculeata) is the best. It is the most fast growing and rank growing leguminous crop there is and as it grows 6 or 7 ft. high in 3 months (June, July and August), it is an excellent crop to cut and plough in at the end of August in preparation for October or November sowings. The Sibpur Farm experiments with potatoes have given most unmistakeable evidence regarding the high value of *dhaincha* as a green-manure for the potato crop. It should be remembered that the first stage of putrefaction with excess of moisture gives rise to the evolution of some H_2S gas, which is poisonous to plants. Aerification by constant cultivation from the end of August to the end of October or middle of November converts the sulphides into sulphates which are valuable as plant food. Destruction of weeds and luxuriant plants growing by the edges of fields when they are in flower (*i. e.* before seeding) and using them as manure, serves also the purpose of destroying a natural harbour of pests and parasites. Other crops used in other countries for green-soiling are, mustard, turnips, rape, tares, rye, lucerne, lupins, spurry, and clover.

Residues of many crops and shed leaves after harvest may be considered as a kind of green-manure. In roots and stubbles usually half of the quantity harvested is left, but in the case of leguminous crops the residues are of equal value or of double the value of the crop harvested, from a chemical or manurial point of view. Root-crops (potatoes, cabbages &c.) leave very little residue behind and are therefore more exhausting than other crops. Barley leaving little residue should be considered an exhausting crop for the surface soil. Lucerne, a perennial leguminous fodder crop, leaves as much as 4 tons of crop residue in the top 10″ of soil and it may therefore be regarded as a very useful crop for fertilizing soils. The residue of 4 tons of vegetable matter contains over 100 lbs. of N.

856. Of other easily available nitrogenous manures may be mentioned sea-weeds and *aquatic weeds* generally which may be applied at the rate of 10 to 20 tons per acre. In fresh state they contain 70 to 80 per cent. of water and 10 to 14 per cent. of ash which includes sand. The true ash is only 3 or 4 per cent. The nitrogen varies from ·15 to ·5 per cent. usually about a quarter per cent. They are not so valuable as farmyard manure, containing only half the proportion of N, but young aquatic sea-weeds are richer in N and K_2O. The value of sea-weeds &c. is however greatly enhanced by the presence of shells and animals and animal remains, which raise the percentage of P_2O_5 and N. Where weeds are available in large and inexhaustible quantities, it is advisable to use them as fuel and then carefully collect the ashes for manure.

857. *Straw* is another readily available manure. The value depending on the proportion of N and of ash. Straws of cereals rarely contain more than ·4 per cent. of N and 4 per cent. of ash. Straws of leguminous crops, however, often contain as much as 2 per cent. of N. Straws are more valuable as cattle food than as manures, except barley straw,

which has a tendency to produce colic. Perfectly ripe straw is not so wholesome as fodder nor so valuable as manure. When too ripe leguminous straws are poorer in N than cereal straws.

858. *Saw-dust* is a poor manure especially if there is much resinous matter in the wood. The saw-dust from gas-works absorbing a large proportion of ammonium sulphate is a good manure. Saw-dust improves the mechanical texture of soils, and it should be utilized wherever available.

859. *Leaves* of trees either ploughed in or first used as litter and then applied to fields as manure are a fairly good fertilizer. Their composition varies, but usually leaf-mould contains ·5 to 1 per cent. of N, ·1 to ·3 per cent. of K_2O and ·1 to ·4 of P_2O_5. Sedges, rushes, and ferns are richer in potash. Peat is sometimes used to fertilize soils, as it is fairly rich in N and often very rich in ash constituents, (5 to 20 per cent.) especially P_2O_5 and $CaSO_4$, which, however, are slowly decomposeable. Peat may be used in cowhouses and stables as it absorbs liquid manures well. Cocoanut fibre has scarcely any manurial value. When fresh it contains only ·06 per cent. of N and when dry ·2 per cent. Tannery refuse also decomposing very slowly is a poor manure. It should be burnt and the ash used as manure. Of all vegetable manures, oil-cakes are richest in nitrogen. Rape-cake, earth-nut oil-cake, cotton-cake, linseed-cake and cocoanut-cake, should be first used as cattle food and the excrements applied as manure. Oil-cakes getting mouldy or rancid, and such oil cakes as mustard-cake, *neem*-seed-cake, castor-cake and *mahua*-cake, should not be used as cattle-food, but as general-manures in preference to dungs.

860. *Seeds* of all plants are richer in manurial constituents than flowers, and flowers richer than leaves, and leaves richer than stems. Rape-cake used alone for turnips and potatoes encourage too luxuriant growth of leaves. It should be used along with phosphates. Two cwt. of oil-cake is a sub-

stitute for 1 ton of farmyard manure and the two manures may be used mixed together. Oil-cake is more effective in moist soil and in wet weather than in dry soil and in dry weather. Rape cake, *neem*-seed-cake and castor-cake are specially valuable as they inhibit the attack of insects. Rape-cake contains $3\frac{1}{2}$ to 5 per cent. of N, $1\frac{1}{2}$ to $3\frac{1}{2}$ per cent. of P_2O_5 and twothirds of this latter quantity of K_2O, the total ash being $4\frac{1}{2}$ to $7\frac{1}{2}$ per cent. Castor oil-cake, mustard-cake and *mahua*-cake are poisonous to cattle.

861. Sugar-cane refuse (called 'megass') is a fairly good manure as it contains ·5 per cent. of N. Refuse from sugar-refineries *i. e.* bone-charcoal containing albuminoid and other impurities, is a very good manure, especially if it is used powdered first in closets and the night-soil mixed up with this powdered charcoal used as manure. The utilisation of bone-charcoal refuse of sugar-refineries in a powdered state by municipalities and its subsequent use for cropping in trenching grounds would be a great agricultural and sanitary improvement.

862. *Coal* contains 1 per cent. of N. which occurs in a very inert form to be of much manurial use. In process of distillation in gas works, however, about $\frac{1}{3}$rd of this is converted into NH_3. some into CN, some into organic bases such as aniline, a considerable portion being left in the coke, and a little is given off as free N. With the addition of H_2SO_4 the ammonical liquor is evaporated and the residue is $(NH_4)_2SO_4$. This crude ammonium sulphate of gas-works contains ammonium chloride and ammonium thio-cyanate. This last named constituent is poisonous to plants and the crude ammonium sulphate is, therefore, re-crystallised and purified before it is sold. The ammonium sulphate of commerce contains 24 to 25 per cent. of NH_3. When pure, $(NH_4)_2SO_4$ contains 25·5% of NH_3. The ammonical liquor of gas works contains about $2\frac{1}{2}$ per cent. of NH_3 *i. e.* about 4 ounces of NH_3 per gallon. Each ton of coal distilled produces 10 gallons of liquor.

Besides NH_3, this liquor contains ammonium chloride, ammonium carbonate, ammonium sulphide, ammonium sulphate, cyanogen compounds, hydrocarbons, and organic bases. If gas-liquor is used for irrigating crops it must be diluted with 4 or 5 times its weight of water.

863. If *Ammonium Sulphate* is purchased for manure, it should be seen that it is very pure, *i. e.* containing 97 or 98 per cent. of pure $(NH_4)_2SO_4$. The purity can be judged by the following tests: (1) if a small quantity is heated it should leave no residue of Na_2SO_4, for instance; (2) it should be dry, and (3) it should be crystalline in appearance. It is an excellent manure for lands naturally rich in phosphates and it is profitably applied to cereals and grasses. It does not act so quickly as Sodium or Potassium nitrate. Like Sodium and Potassium nitrates, Ammonium Sulphate does no good to leguminous crops. For sugar-cane, it is a favourite manure.

864. *Sodium nitrate*, imported from Chili and hence called Chili Saltpetre, contains 15 to 16 per cent. of N. Three parts of Ammonium Sulphate are equal to 4 parts of Sodium nitrate as far as N is concerned. $NaNO_3$ contains more N than KNO_3. It gives larger increase of crops than either KNO_0 or $(NH_4)_2\ SO_4$ and it is an excellent top-dressing for cereals and grasses, but it and the Sulphate should not be used too freely without phosphatic and potassic manures. When cereals show a tendency to run too much to straw, NaCl should be applied mixed up with $NaNO_3$. One cwt. per acre is the usual dose both for Ammonium Sulphate and Sodium Nitrate. In England the values of Ammonium Sulphate and Sodium Nitrate are about the same, *i.e.*, £11 per ton, which is rather more than *Rs.* 5 per maund. We cannot expect to get either of these articles for less than *Rs.*7 per maund in this country, and as KNO_3 is on the whole a better manure, the use of this only is recommended for this country. The conversion of each municipal trenching ground into a regular nitre-bed where crude saltpetre for agricultural

use may be systematically manufactured for sale to cultivators would afford a great sanitary and agricultural object lesson to village unions and other rural and local bodies, and the subject is earnestly put forth for the consideration of students of Indian Agriculture.

865. Of other easily available nitrogenous manures may be mentioned *blood*, which contains 3·7 per cent. N and 5 to 15 per cent. in the state of "dried blood", as blood is dried usually with the addition of gypsum and H_2SO_4. Blood contains 23 per cent. of dry matter *i. e.* almost as much as flesh which contains 25 per cent. of dry matter and 4 per cent. of N. *Flesh* after boiling and drying contains 12 per cent. of water 9 to 9½ per cent. of N, 4 per cent. of Phosphates. Boiling is done to get rid of the fat. *Skins*, *hair*, *horn*, and *feather* contain in their natural state 4 to 8 per cent. of N and in dry condition about 15 per cent. Carcasses of animals espicially horses subjected to the action of steam and reduced to a pulp by the addition of H_2SO_4 and mixed with super, are also used in Europe as "Turnip manure." In India we can bury the carcasses with the addition of some lime in agricultural land, and village unions may be entrusted with the duty of proper burial of carcasses. A carcass weighing 500 lbs. yields 12 lbs. of NH_3, 24 lbs. of P_2O_5 and 14 lbs. of K_2O. Woollen rags and refuse called 'shoddy' are also a good manure containing 5 to 9 per cent. of N, equivalent to 6 to 10½ per cent. of NH_3. Cotton and Jute refuse are, however, almost useless as manure. Leather though it contains as much as 5½ to 6 per cent. of N is also useless as a manure, as the process of tanning renders the N undecomposeable. Refuses from glue and tallow-making factories, rum and spirit factories, indigo, sugar and silk factories, are also valuable manures. All animals, as fish, frogs, snails &c. are valuable as manure when available in large quantities. When dry they contain 5 to 7 per cent. of N and 12 to 18 per cent. of P_2O_5. Refuse of fishes

&c., contain about 5 per cent. of N and 5 to 30 per cent. of phosphates, and is called fish-guano. *Soot* is top-dressed as an insecticidal manure chiefly on cereals. Its manurial value depends on the proportion of NH_3, it contains, which varies from 1 to 4 per cent., the average being about 2 per cent. Soot consists mainly of finely divided carbon with from 16 to 40 per cent. of mineral matters.

866. *Guano* is another nitrogenous manure which is largely used in England and America, but which we are not likely ever to make use of. It is applied at the rate of 2 to 3 cwts. per acre (= 50 to 60 lbs. of NH_3, and 100 lbs. of P_2O_5). Two classes of guano are distinguished. Of these the nitrogenous guanos obtained from the dry regions of Peru, contain as much as 2 per cent. of N and 12 per cent. of P_2O_5 and the Phosphatic guanos obtained from west regions ·9 per cent. of N, 32·5 per cent. of P_2O_5 and 3 to 4 of K_2O. Being very variable in composition it is usually purchased on analysis. Bird's dung and bat's dung containing more moisture about (25 per cent.) are, weight for weight less valuable. But dried, they are of equal value to guano (1½ to 10 per cent. NH_3 and 6 to 30 per cent. Phosphates).

867. While on this subject of nitrogenous manures we may once more revert to the question of *utilization of sewage* and study the methods that have been devised for making town-sewage inoffensive and less objectionable for use as manure. We have already recommended the use of dry earth, powdered charcoal and trenching with the addition of lime. Green vitriol ($FeSO_4$), alum and lime are in use in Europe for rendering human excreta inoffensive. In the case of urine, calcium and magnesium phosphates are used. Attempts to purify sewage by precipitation and filtration cannot be said to have passed the experimental stage. One of the processes adopted for agricultural purposes is called the 'A, B, C process', the constituents used for precipitating being alum, blood and clay. The precipitate is sold as

"Native guano", which is mixed with super to make it a richer manure.

868. Another process applied is that of cultivating deodorising bacteria in tanks protected from sunlight through which the sewage is made to run. Electric processes have been also applied with more or less success in purifying sewage.

869. In England it has been estimated that for every head of population 40 to 60 tons of sewage is formed per annum. This is not absolutely wasted as the fish and sea-weeds are nourished by it. These 40 to 60 tons consist mainly of water, solid and liquid excrements forming only small proportion of the sewage. This quantity contains only about 10 lbs. of N calculated as Ammonia. The conclusion drawn from experiments conducted in sewage-farms in England is, that by the use of 5,000 tons of sewage per acre 30 tons of grass may be expected, and the value of sewage has been calculated at $\frac{1}{2}d.$ to $1d.$ per ton. Leguminous plants are killed out in a pasture manured with sewage water. Weight for weight unsewaged grass is better fodder than sewaged grass, but for equal weights of dry matter the sewaged grass which is richer in N has a better nutritive value. Milk increases in quantity but is reduced in quality with sewaged grass, but cows kept on sewaged grass, if they are given some oil-cake every day thrive beautifully and give good quantities of rich milk. From 5000 tons of sewage applied judiciously to 1 acre, about 75 maunds of milk may be expected per annum, as 30 tons of green grass would keep 3 cows for 1 year, each cow being allowed 30 seers of green grass and one seer of oil-cake per day ($\frac{30 \text{ tons} \times 28 \text{ mds.} \times 40 \text{ srs.}}{30 \text{ srs.} \times 365}$ = about 3) and the average yield per cow (if a select class is kept) may be taken at 5 seers per day for 200 days per annum. The rent of the land being calculated at Rs. 10 and the value of the oil-cake (3 srs. × 365 days) at Rs. 60 and the cost of irrigation

with sewage at Rs. 144 (2 men employed for pumping out the sewage with a *dôn* and distributing the same and also tending the cattle), the total expense may be put down at Rs. 214. The value of 75 maunds of milk at 12 srs. to the Rupee comes to Rs. 250. This calculation gives some practical idea of the small value per ton of sewage and the difficulty of utilising it in places where a large capital would be required to make use of sewage, or where milk does not command a ready sale, or where land is dear. But it also shows that in favourable localities grass farms can be made to yield large profits by the use of sewage, and the Government Grass Farm at Allahabad is a case in point.

870. Cabbages, mangolds and straw-berries have been also grown successfully with sewage. Light soil resting on sandy or gravelly subsoil is the best for sewage irrigation. Sewage water should never be sprayed or sprinkled over a crop, but always applied to the land put up in ridges, along furrows. It should not be used at the last stage of the growth of a crop.

871. Animal manures, such as flesh, blood &c., are better than vegetable manures, as they contain more N, and decompose more readily in the soil giving up greater quantities of plant-food to crops in a shorter time.

CHAPTER LXXXIX.

PHOSPHATIC MANURES.

MINERAL phosphates.—Phosphates occur in soil and rocks chiefly in the form of *Apatite*. As a rule, crystals of apatite occur in microscopic dimensions, but occasionally rich deposits of apatite crystals, several inches in length and

2 or 3 inches in diameter, are come across. Such a deposit has been recently discovered in the mica mines of the Koderma forest, Hazaribagh, and it promises to be of great value to Indian Agriculture. Messrs. Ewing & Co. are selling the uncrushed mineral at Rs. 2 per maund and in the crushed state at Rs. 3 per maund. As the crushing can be done with an ordinary *dhenki* provided with a block of granite or basalt at the base of the mortar, at a cost of about 2 annas a maund, it is best to procure the crude mineral. In pure state, apatite contains 90 to 92 per cent. of tricalcic phosphate, and its formula is either $3Ca_3P_2O_8 + CaCl_2$ or, $3Ca_3P_2O_8 + CaF_2$, according as to whether the mineral contains Chloride or fluoride of Calcium, though it frequently contains both. In the natural state, in which it occurs in Hazaribagh, it contains many impurities, *e. g.* quartz and mica; crystals of felspar being also associated with the mineral. In this state, Mr. D. H. Holland, Superintendent of the Geological Survey of India, has found 76 per cent. of tricalcic phosphate in the Hazaribagh apatite.

873. Occasionally phosphates occur in rocks and soils in the form of *phosphorite* crystals ($Ca_3P_2O_8$) without being combined with calcium chloride or fluoride.

874. *Weavilite,* which is hydrated aluminium phosphate, is another fairly common mineral, but we can ignore consideration of this for manurial purposes, as it does not occur in sufficient abundance anywhere.

875. In the Nepaul valley there is a clay which is actually used as manure, which is rich in a phosphatic mineral (*vivianite*).

876. Hard *phosphatic nodules* occur in fair abundance at Trichinopoly. These contain nearly 57 per cent. of $Ca_3P_2O_8$ (equivalent to about 26 per cent. P_2O_5) and about 16½ per cent. of $CaCO_3$. They are as difficult to crush as coprolites.

877. *Coprolites* are probably fossil dung of extinct animals. There are rich deposits of these in many countries,

and they contain from 30 to 80 per cent. of $Ca_3P_2O_8$. The Trinchinopoly nodules may be classed as coprolites of a superior kind.

878. *Bones*, bone-dust, bone-shavings and ivory-shavings are also very rich in phosphates. They contain from 45 to 55 per cent. of phosphates chiefly as tricalcic phosphate, and partly also in the form of magnesium phosphate. Bones containing also $3\frac{1}{2}$ to $4\frac{1}{2}$ per cent. of nitrogen, 3 per cent. of $CaCO_3$ and 4 per cent. of alkaline salts (including silica), may be regarded in the light of a general manure also.

879. *Boiled bones* (whole or dust) are richer in phosphates (45 to 60 per cent.), calcium carbonate (3 to 9 per cent.) and alkaline salts including silica ($4\frac{1}{2}$ to 13 per cent.), but they are poorer in nitrogen ($1\frac{1}{2}$ to 3 per cent.).

880. *Animal charcoal* is still richer in phosphates (64 to 87 per cent.) but poorer in the other substances. Bone-ash contains as much as 77 to 88 per cent. of phosphates and 4 to 6 per cent. of calcium carbonate, but it contains no nitrogen.

881. The *slag* of iron foundries is another important source of phosphatic manure, sometimes containing the equivalent of as much as 78 per cent. of $Ca_3P_2O_8$.

882. As far as phosphates are concerned, apatite, therefore, may be considered the richest and the cheapest substance to use. It is much cheaper buying apatite at Rs. 2 or even Rs. 3 per maund than bone-dust at Rs. 2 per maund. In itself however it is not a complete manure, as it contains no nitrogen or potash. With the addition of potassium nitrate or saltpetre, apatite forms a most valuable manure. It should be noted, however, that like bone-dust, or coprolite, apatite is also a highly insoluble substance. By the addition of sulphuric acid, bone-dust, or powdered apatite and coprolite, may be converted into *super* which readily dissolves in the soil, but, on the whole, it is better to use these substances finely powdered, but not converted into super, as a fertiliser of the soil, without expecting any immediate benefit in

return. If it is applied to crops that take a whole year growing, and crops, such as root-crops, and sugar-producing crops, that are specially benefited by the application of phosphatic manures, good result, no doubt, will immediately follow, *i.e.* it will be palpable in the very first crop grown with this manure. It is best, however, to apply a fairly heavy dose of powdered apatite (say 10 maunds per acre) every 5 years, and grow a crop of sugar-cane the year it is first applied, to make the best immediate use of the fertiliser.

883. The *detection of phosphoric acid* in rocks and minerals, is of the greatest value to agriculturists. It can be done by finely pulverising a tolerably large sample of the substance, digesting it in Hydrochloric acid, filtering off the solution and treating it with Ammonium Molybdate. If phosphoric acid be present, a yellow precipitate will follow, and the precipitation which usually takes place very slowly, may be accelerated by frequent stirring with a glass rod.

884. When a substance contains more than 3 per cent. of phosphoric acid, its presence may be detected in a dark room by the flame test. A little of the mineral, or substance to be tested, is powdered and made into a stiff paste with water. Then a heated loop of platinum wire is to be dipped into this paste and returned to the flame of the spiritlamp (or blow-pipe). If phosphates are present, a characteristic dull green flame will be given out, which in a dark room cannot be mistaken.

885. Apatite, though a very insoluble mineral, is readily dissolved in hydrochloric acid. For the flame test also a little hydrochloric acid may be used *i. e.* the red-hot platinum loop with the substance tested may be dipped in a bottle of hydrochloric acid and held over the spirit lamp again. Chlorides usually give the best colorations. Hence the importance of using hydrochloric acid in testing minerals for phosphates.

886. *Bones.*—Phosphatic manures are of very great im-

portance as though the available phophates in Indian soils are probably not deficient and though there is no immediate possibility of Indian soils getting barren for want of phosphates, yet the total amount of phosphates in Indian soils is relatively so small and the denudation of phosphates by the export of bones, grains and oil-seeds, is so persistent, that the question of supplying phosphates to soils by way of fertilizers must sooner or later assume the most serious importance.

887. The most readily available source of soil fertilization so far as phosphates are concerned, is bone. The effect of bones used in large pieces is slow, but they should be applied in this state only, when fruit trees are planted. It is curious Nepalese have the custom of putting a number of bones in each pit made for planting fruit trees and they say this makes the fruits sweeter for all times. It is a right notion and if this custom of stowing away bones under fruit-trees had been widely followed bones would not have lain neglected and been carried away from India to other countries for purposes of manure.

888. Of the phosphates in bones, 2 per cent. occurs as $Mg_2P_2O_7$ and the remainder as $Ca_3P_2O_8$. Bones are steamed or boiled for making glue and gelatine. The greater part of the organic matter is removed in this process. Steamed and boiled bones though richer in phosphates contain less N; but on the whole, they are preferred for manure. Burnt bone or animal-charcoal is used in sugar-refineries. The refuse animal-charcoal of sugar-refineries is a superior general manure. Bone-dust, bone-shavings and bone and ivory turnings are of equal manurial value. Five to six maunds of finely powdered bones per acre is a good fertilizer for grass lands and cereal crops, larger quantities being used for sugarcane and root-crops.

889. Bones, in country places, where crushing mills are not available, may be reduced to powder by means of caustic

lye (solution made out of ashes), quick lime or freshly calcined wood ashes. A simple plan is to pack the bones layer by layer, with freshly calcined wood ashes, in a barrel, and keep the mixture moistened for some months. Casks or old packing cases may be kept in constant use for this purpose on a farm, and bones and ashes may be put layer after layer as they are collected.

890. A quicker method is to boil the bones in an iron or copper boiler with strong caustic lye. The proportion of bones and lye to be used is roughly 15 parts by weight of bones to 5 parts by weight of caustic soda or 7 parts by weight of caustic potash dissolved in 15 parts by weight of water. The boiling should be done for 2 or 3 hours. But even without boiling the bones will become disintegrated being simply kept in the caustic liquor for about a week.

891. Another method of softening bones is by mixing them in heaps with quicklime and loam. A layer of loam 4″ deep is first spread, and on this is put a layer of bones 6″ deep and above this a layer of quicklime 3″ deep. The layers of loam, bones and quicklime are repeated until the heap reaches a convenient height, when it is covered all over with a thick layer of earth. Holes are then bored in the heap from the top and water poured down them to slake the lime. The mass will become hot and remain so for 2 or 3 months after which the bones will become friable and the whole heap may then be mixed up and spread as manure on land.

892. Another method of bringing bones into a fine state of division without the help of a mill is to mix themwith half or a third of their weight of clay or earth, saturating the mixture with urine, placing it in a pit and covering the pit up with 2 or 3 inches of earth. In 2 or 3 weeks the bones get disintegrated and the addition of urine makes them a better general manure. Fermented bones act more readily in the soil, and they are more valuable than bone-meal for light soil.

893. *Super.*—In Europe the rapidity of the action of bones in soil is increased by treatment with sulphuric acid, by which tri-calcic phosphate is rendered soluble being converted into monocalcic phosphate. Bones, boneash and mineral phosphates, powdered and treated with sulphuric acid go to form the manure known as 'super' or super phosphate of lime.

894. Caprolites are harder still than bones and even in a powdered state they act slowly in the soil, and they are more difficult to grind than bones. Dissolved with sulphuric acid, bones, coprolites and apatite resolve themselves into *super*. More than half a million ton of super is made annually in England alone for manurial purposes, the reaction that takes place may be expressed by the formula $Ca_3P_2O_8 + 2H_2SO_4 = CaH_4P_2O_8 + 2CaSO_4$. The sulphuric acid first decomposes the $CaCO_3$ present and manufacturers therefore do not like the presence of much $CaCO_3$ in the bones or minerals used.

895. The sulphuric acid used in the manufacture of super is 'chamber acid,' which is the cheapest of the three kinds of commercial sulphuric acid, known respectively, as Oil of Vitriol (sp. gr. 1·89), Brown Acid (sp. gr. 1·72) and Chamber Acid (sp. gr. 1·6). It contains about 69 per cent. of H_2SO_4. 100 parts of pure $Ca_3P_2O_8$ require 91 parts of Chamber acid to act on it, while 100 parts of $CaCO_3$ require as much as 140 parts; 100 parts of Fo_2O_3 require 262 parts and 100 parts of Al_2O_3 require as much as 405 parts of Chamber acid to act on the Fo_2O_3 and Al_2O_3 respectively. The freer therefore the mineral is from $CaCO_3$, Fe_2O_3 and Al_2O_3 the better it is.

896. Super is manufactured in the following way:—The raw bones or mineral phosphates are finely powdered with a powerful mill. This powder is placed in a closed vessel or chamber which is called mixer, the necessary quantity of sulphuric acid being dripped into the chamber by slow degrees from a tank above it. The gases given off pass out through a long tube where they gradually condense and pass out in

liquid form. As some of the gases are dangerous to health this condensing of the gases or vapours passing out is very necessary. The gas given off is chiefly CO_2, but HF, SiF_4 and Iodine vapour are also given off. As the acid is gradually let into the powdered mineral a strong shaft provided with rakes keeps the powder continually agitated. When the proportional quantity of acid has been used up and the mixing completed the contents of the chamber (which is usually $\frac{1}{2}$ a ton to 1 ton) is allowed to fall into a brick or stone-ware chamber known as the "den," which when full is closed and allowed to remain there until its temperature is reduced, the rise of temperature being due to the mixing of the phosphates with the acid.

897. The contents of the 'den' are afterwards dug out and passed through a 'disintegrator' which renders the manure into a powdery condition in which state it is sold. Unless sulphuric acid can be manufactured on the premises in a super factory, it does not pay to make super. The question of using super in this country is beyond the pale of practical agriculture, if sulphuric acid has to be purchased. But a sulphuric acid manufactory can profitably make super as well, if a market for this manure can be created, say among European planters. Super manufacturing has been actually commenced in one of the islands of the Malay Archipelago, where phosphatic deposits of great purity have been discovered. Messrs. T. Stanes & Co. of Coimbatore also manufacture and supply super and other concentrated manures.

898. Super is usually mixed with blood, soot and refuse vegetable and animal matter of all kinds or with $NaNO_3$ or $(NH_4)_2\ SO_4$ to convert it into a general manure. The composition of super varies very much according to the mineral used in its manufacture. Oxide of iron, aluminium and magnesium and free phosphoric acid (H_3PO_4) are almost always present. The whole of the bone or mineral is scarcely ever acted upon by the acid. Ordinarily super contains 25 to 28 per cent. of soluble phosphates, but it is possible to have super with as

much as 45 per cent. of soluble phosphates calculated as $Ca_3P_2O_8$. The soluble phosphate of the manufacturer is not $CaH_4P_2O_8$, but is expressed in the terms of $Ca_3P_2O_8$ which have been rendered soluble. 20 per cent. of soluble phosphates means 20 per cent. of $Ca_3P_2O_8$ made soluble which is actually 15 per cent. of monocalcic phosphate ($CaH_4P_2O_8$). Super is sometimes said to contain so many per cent. of biphosphate (CaP_2O_6), in which case the soluble phosphate instead of being expressed in the terms of monocalcic or tricalcic phosphate, is expressed in terms of the so called biphosphate which is properly speaking calcium metaphosphate, obtained by drying monocalcic phosphate.

$$CaH_4P_2O_8 = 2H_2O + CaP_2O_6.$$

Now the molecular weight of P_2O_5, $CaH_4P_2O_8$, CaP_2O_6, and $Ca_3P_2O_8$ are respectively 142, 234, 198 and 310. Taking $CaH_4P_2O_8$ as unit, $Ca_3P_2O_8$ and CaP_2O_6 bear the proportion of 1·33 : ·85. Super is also sold at so much "per unit," unit meaning 1 per cent. of soluble phosphate per ton. The insoluble phosphates are not valued in purchasing mineral super after analysis, but in purchasing bone-super the insoluble phosphates are also valued.

899. The following table gives the percentage compositions of the principal varieties of super :—

	Bone super.	Super from bone-ash.	Mineral super.	"Concentrated super."
Moisture ...	8 %	6 %	15 %	13 %
Organic matters and combined water ...	21 „	5 „	12 „	6 „
$CaH_4P_2O_8$ ...	15·1 „	26 „	18 „	30·1 „
(=$Ca_3P_2O_8$) ...	[20 „]	[34·5 „]	[28·3 „]	[40 „]
$Ca_3P_2O_8$ ...	15 „	5 „	6 „	2 „
$CaSO_4$ ...	36 „	54 „	42 „	44 „
Alkaline salts, &c.	1·9 „	1 „	·5 „	·4 „
SiO_2 ...	3 „	3 „	6·5 „	4·5 „
N (=NH_3) ...	2·5 „ to 3 „	·3 „	Nil.	Nil.

900. When soluble phosphates cost 3*s*. per unit (*i. e.* for 1 per cent. per ton), a ton of super containing 40 per cent. of $Ca_3P_2O_8$ in the soluble form (as $CaH_4P_2O_8$) would be valued at 40 × 3 *s*. = £6. The price of insoluble phosphates in bones is £5 to £10 per ton, of soluble phosphates £ 15 per ton and of reduced or dicalcic phosphate ($Ca_2H_2P_2O_8$) £10 to £12 per ton.

901. Super kept for a long time is reduced in its solubility in water by 5 per cent. or more of the total phosphates. This reduction takes place chiefly in supers containing Al_2O_3 and Fe_2O_3. The ferric and alluminic phosphates and the tricalcic phosphates formed are insoluble in water. Dicalcic phosphate ($Ca_3P_2O_8 + CaH_4P_2O_8 = 2Ca_2H_2P_2O_8$) is not altogether insoluble in water. In the precipitated phosphates of glue manufactures, gelatine works and those manufactured from basic iron slag of iron foundries, the phosphates occur as dicalcium phosphate. This form of phosphate occurs in some guanos also. It is more soluble in water charged with CO_2 and in saline solutions. Dicalcic phosphate threfore is found to be of equal manurial value with monocalcic phosphates in certain soils. In sandy soils and soils containing little lime, dicalcic phosphate (called also ' reduced' or ' retrograde' phosphate) gives better result than monocalcic phosphate, and even tricalcic phosphate in a finely divided state is sometimes found to give better result in such soils than the soluble monocalcic phosphate. The reason for this is, that when soluble phosphate comes in contact with soil, the phosphate is immediately precipitated (but not in sandy soils or in soils deficient in lime) in a gelatinous form, in which state it is extremely soluble though not easily washed out, and it gets diffused through the soil very easily and quickly. It gets gradually reduced and converted into dicalcic phosphate, afterwards into tricalcic phosphate and eventually into phosphates of iron and aluminum. But in sandy soils and those containing little lime, the gelatinous precipitation does not take

place at once, and soluble phosphates are apt to get washed away before complete precipitation takes place. In such soils therefore it is best to apply phosphates in a less soluble form. Soils poor in lime treated with super may get too acid, and lose in absorptive power and capacity for nitrification. On the whole, it is better especially for India, to use finely divided bone-dust or mineral phosphates without dissolving them with sulphuric acid, though more marked immediate result is obtained from the use of super. 5 maunds of super per acre is the best quantity to use for root-crops and 2½ maunds for cereals. A crop of 150 maunds of potatoes takes up only about 10 lbs. of P_2O_5, while 5 maunds of bone-dust adds about 90 lbs. of P_2O_5 to the soil.

902. In estimating the amount of soluble phosphates, cold water should be uniformly used. Phosphate of Alluminum is less soluble in hot water than in cold and when it is in solution in water it is precipitated by heating. In estimating the amount of reduced phosphate, the substance should be treated with a neutral solution of Ammonium Citrate (Sp. gr. 1·092). This has little action on insoluble phosphates but it dissolves those that have been once soluble and then become precipitated. The *precipitated phosphates from the slag of iron foundries* are very rich in dicalcium phosphate, the proportion being equivalent to 32 per cent. of P_2O_5 or 78 per cent. of $Ca_3P_2O_8$. The whole of this is soluble in a solution of Ammonium Citrate. On soils rich in humus, basic slag, therefore, acts as a very rich manure.

903. *Effect of phosphatic manures.*—Phosphatic manures hasten the development of young plants, make them so healthy that they resist the attack of insect pests which thrive better on weakly plants. They also hasten maturity, increase the flowering and fruiting tendencies of plants, and assist in the elaboration of sugar and starch.

904. *Available phosphates.*—According to Dr. Dyer of London, there should be at least 300 to 400 lbs. of available

phosphoric acid per acre within a depth of 9″, *i. e.* ·01 per cent. of P_2O_5 soluble in a 1 per cent. solution of Citric acid and most Indian soils have more than this. Total phosphoric acid may be determined by the use of strong HCl which dissolves the whole of lime and phosphoric acid though only a portion ($\frac{1}{4}$th to $\frac{1}{40}$) of the potash. A soil containing 700 or 800 lbs. of available P_2O_5 per acre within the first 9″ would probably show 2,700 to 3,000 lbs. of total P_2O_5. Of the 700 lbs. of available P_2O_5, a crop of 1,000 lbs. of wheat or rice per acre removes from the soil only 7 lbs. of P_2O_5 in either case. The straw in each case removes another 3 lbs. of P_2O_5 which is returned to the soil in one form or another. In the case of paddy 3 lbs. per acre go to the husk, 4 lbs. to the rice and 3 lbs. to the straw, the total quantity being the same as in the case of wheat, though the outgoings if the husk and the straw are returned to the soil are less in the case of paddy. The gain of phosphoric acid by silt deposition and irrigation is a good deal more than the outgoings and it is only where no silt-deposit or irrigation takes place that the question of recoupment of phosphoric acid in Indian soils need be considered. So far phosphatic manures have given no decisive results in the experimental farms of India, and the value of manures should be principally judged from the proportion of N they contain. Well-water used for irrigation purposes is much richer both in phosphoric acid and N than rain or canal water. Rain-water contains no phosphoric acid and only 4 parts of N in 10 million parts. Clear canal water usually contains only 2 parts of N and 10 parts of P_2O_5 in 10 million parts and muddy canal-water, 4 parts of N and 20 parts of P_2O_5 in 10 million parts, while well-water may contain 150 parts of N and 100 parts of P_2O_5 in 10 million parts.

CHAPTER XC.

POTASH MANURES.

MINERAL potash.—Potash occurs in nature in felspars and mica, which enter into the composition of every soil. The pink coloured orthoclose felspar which is so common in Indian granites, is richest in potash. In felspars, potash is contained in a more soluble form than in mica, and its solubility is enhanced by admixture with lime. Zeolites also contain potash and being more soluble than ordinary felspar (with which they resemble in composition) are good fertilisers, and they are abundantly present in some soils. Potassium sulphate (K_2SO_4), potassium chloride or sylvine (KCl), potassium nitrate, and Kainit, also occur in nature.

906. For ascertaining whether a substance contains potash or not, the flame test may be employed. Potassium gives violet flame; the flame effect of sodium, of course, must be eliminated by the use of dilute hydrochloride acid.

907. In Europe, potash manures are used chiefly in the form of Kainit which is obtained from Prussia where it occurs as a natural deposit at Stassfurt. Very few soils need potash manures as mere plant-food, as usually there is enough of available potash in every soil. The composition of Kainit is represented by the formula K_2SO_4. $MgSO_4$. $MgCl_2$. $6H_2O$. Common salt often occurs in Kainit as impurity. Ordinary Kainit contains 13 to 15 per cent. of K_2O and Calcined Kainit 17 to 18 per cent. Concentrated potash salts are made out of this. Other sources of potash manure are the mother liquor from sea water after the extraction of common salt and vegetable ashes.

908. *Organic potash.*—The commonest potash manure is ashes of all kinds. Liquors obtained by distillation of beet and

extraction of sugar from beet or sugar-cane, are rich in K_2O. Crude *gur* contains a great deal of KNO_3 and the refuse of sugar factories is therefore rich in potash. Wood-ashes contain 5 to 7 per cent. of K_2O; straw-ashes less. Wool and hair are particularly rich in K_2O. Ashes obtained from all tender and green parts of plants are, as a rule, rich in potash, *e. g.*, ashes of sun-flower stalks, of plantain and other tender leaves, of maize-stalks, of sugar-cane refuse, of tobacco leaves and midribs, &c. All such ashes or substances should be carefully stored in the manure-pit. Potash manures are particularly helpful to the growth of leguminous crops, leafy crops, root crops *e. g., yams, ôl, kachu, potatoes,* gram, groundnuts, cabbages &c. Silt, especially fine dark coloured silt, brings so much of potash in an available state that no potash-manure need be applied to any land which is occasionally renovated with silt. Irrigation water also brings sufficient potash, as it contains about 10 to 20 parts of K_2O in a million parts. Rain water, of course, contains no K_2O. Potassium nitrate and cattle urine are the best potash manures ordinarily available. The urine of poorly-fed cattle is richer in potash than the urine of well-fed cattle, because the former feed principally on grass and straw which contains a larger proportion of potash than better food materials.

909. *Compost.*—In making compost it is better to use ashes than lime and salt. The object of using an alkaline substances as manure is to hasten its decomposition. As potash is in itself a more valuable food substance than lime or soda, ashes containing some lime and soda in addition to potash are to be preferred. The power of potashes to make the N of the soil available for plants is also well known and the application of potash manures is therefore of great, indirect value. Ashes also increase the capillarity of the soil and Lorain observed that the ground where log-heaps had been burned was moister than the surrounding soil. Indeed excess of alkali is often outwardly recognizable by the puddly

character of clay which is difficult to drain. Hilgard says "soils impregnated with alkaline carbonates may generally be recognised by their extreme compactness and refractoriness under tillage, and by the fact that they are apt to form 'low spots' in the general surface of non-alkaline land, *i. e.* places where turbid clay water, dark with dissolved humus will lie for weeks after the higher land appears dry."

910. The potash in the soil occurs chiefly in the form of hydrated double silicates or hydrated double humates of potash and alumina. Had it not been for the double silicates, the potash in the soil would have been washed out and carried into the sea. Because soda is less readily retained than potash by these double silicates, that the sea water is charged chiefly with NaCl washed out from soils instead of KCl. NaCl is dissolved out from the soil and carried away to the sea by the water of percolation more freely than any other salt. This fact makes it so easy to reclaim saline soils like those of the Sunderban. In the decomposition and disintegration of rocks, soda salts are most readily parted with and washed away into the sea, potash being more or less retained by the soil by absorptive action at the expense of soda salts which are the first to be washed away. In the natural condition, for instance, a piece of basalt may contain 1½ per cent. of potash and 7½ of soda, but the same basalt after decomposition as soil may show equal proportions (about 2½ per cent.) of potash and soda.

911. Potash does not accumulate so much in fruits and seeds as in straw and leaves which are returned to the soil in one form or another. In the building up of animal tissues also potash does not form an important ingredient. In a well managed farm therefore whence grain and animals only are sold, potassic manures will not be found of much use. But that certain crops, such as root-crops, especially beet, potatoes and tobacco are benefited by potassic manure, is a matter of universal experience. It is only where the crops

sold are of a soft kind, such as fodder crops, beet, carrots, cabbages, turnips, onions, potatoes, tobacco, or where straw is systematically sold, that the need of potash manures becomes felt in course of time and these are best applied in the form of ashes. Sun-flower stalks, pea and bean stalks and maize and *juar* stalks being particularly rich in potash, these should not be neglected but carefully put in manure heaps in their bulky state or converted into ashes and the ashes applied to land mixed up with dung and other vegetable manure as compost. 17 to 20lbs. of potash can be obtained from 1000 lbs. of dry sun-flower, pea, bean, *juar* or maize stalks.

912. Potash accumulates more in the extremities of plants, *i.e.*, green leaves and twigs, than elsewhere. 1000 lbs. of wood contains only ½ lb. to 1½ lbs. of potash. Ordinary cereal straw though rich in potash contains it chiefly in the form of silicate of potash which is not readily soluble in water. The ashes of ordinary cereal straws are therefore not such good potash manures as ashes of maize stalks, sun-flower stalks and leguminous crop straws. Tobacco stems divested of leaves are extremely rich in potash. The dessicated stalks contain about 5 per cent. of K_2O, $\frac{7}{10}$ per cent. of P_2O_5 and 3½ per cent. of N, of which $\frac{1}{5}$ per cent. is in the form of nitrate. The refuse tobacco stalks and midribs are therefore a high class fertilizer and may be looked upon as a special potash-manure and also as a general manure. Ashes from cotton seed husk are also a first class potash manure. They contain 18 to 30 per cent. of K_2O in a very soluble condition, also 5 to 10 per cent. of P_2O_5 of which 1½ to 2 per cent. is soluble in water. Lime-kiln ashes contain only 2 per cent. of K_2O and less than 1 per cent. of P_2O_5. Brick-kiln ashes contain only 1½ per cent. of K_2O. These and ordinary wood ashes are therefore not nearly so valuable as ashes derived from burning twigs, leaves and green or soft parts of plants, or from cattle-dung. In applying ashes as manure to crops this very important difference must be

borne in mind. The greater alkalinity is desirable not from a mere manurial point of view, but from the fact that it is the force of alkalinity which enables the ashes to rot weeds and to ferment peat. It should be noted that the Stassfurt salts of potash so largely used in Europe as potash manures are inferior to ordinary wood-ashes for manurial purpose, and there is no occasion for us in India to look from Kainit and other Stassfurt salts. The explanation seems to be that the sulphate and chloride of potash of Stassfurt are devoid of the alkaline quality of carbonate of potash which is the effective agent in ashes obtained from wood, branches, leaves, &c. But merely as a manure or plant food, potassium nitrate is the best potash manure to use. For potatoes, tobacco, and beet, nitrate of potash is now largely used, in Europe and America, and we should all the more readily use it both as a Nitrogenous and as a potash manure as it is a cheap manure for the price at which it can be had in India.

913. *Physiological action of potash.*—Potash plays certain very important parts in vegetable physiology and these may be mentioned here :—

(1) It has been found to be a means of enabling starch to move from one part of the plant to another. This is one reason why potash manures are found particularly adapted for *yams*, *ôl*, potatoes and other root-crops which are valued for their starch. The potash manure helps the freer circulation of starch granules from leaves to roots.

(2) Potash manures are helpful to fruit formation, especially formation of fruits containing sour juices, these fruits containing citric, malic, tartaric or oxalic acid. In most cases these acids are found combined with potash. Jails in Bengal are required to grow lime trees. In Berhampore jail there were hundreds of lime trees that had never borne fruits although they were several years old. The jailor was advised to apply ashes and bones. As there was objection on the part of the

jailor to the using of bones, ashes, and mustard-cake were applied, after the plants were dug up all round. Phosphates also have the power of intensifying flowering and fruiting tendencies of plants. Hence the advice of applying bones also. The application of ashes resulted in profuse formation of lime fruits that very year.

(3) It has been noticed that tobacco leaves charged with potash salts of vegetable acids burn readily, and in a manner quite different from leaves containing an excess of chlorides. Hence Potash salts (not in the form of chlorides but in that of nitrates and sulphates) have been found very appropriate manures for cigar-making tobacco. The presence of much carbonate of potash in tobacco ash, is an indication that considerable quantities of organic compounds or nitrate of potash are confined in the leaves. When subjected to heat the organic potash salts swell up so that the charcoal is left in a spongy, easily combustible condition such as we see when a good cigar is burning, the ultimate product of combustion being carbonate of potash.

914. *Estimation of available phosphoric acid and potash.*—Soils are ordinarily analysed for the estimation of the total Nitrogen, phosphoric acid, potash and lime, there are in them. For the estimation of available phosphoric acid and potash, a fairly satisfactory method has been devised by Dr. Dyer of London. A weight of air-dried soil corresponding to 200 grammes of completely dry soil is taken, and treated in a Winchester quart bottle with 2 litres of distilled water, in which 20 grammes of pure citric acid had been dissolved (*i.e.*, with 2 litres of 1 per cent. solution of citric acid). The soil is left in the solution for a week, during which time it is frequently agitated. At the end of this time the solution is filtered, and a portion of solution corresponding to 50 grammes of soil is taken for the determination of dissolved potash and a like quantity for the determination of dissolved phosphoric acid. The filtrates are evapo-

rated and ignited in platinum crucibles, and the potash and the phosphoric acid in the residue determined in the ordinary way.

915. From a series of experiments Dr. Dyer has concluded, that a soil containing less than ·01 per cent. of available phosphoric acid is in need of soluble phosphatic manures, and a soil containing less than ·005 per cent. of potash is similarly in need of soluble potash manures.

916. It is not of much practical use determining the available nitrates present in the soil, as they vary from day to day specially in the rainy season. It would be of greater importance to determine the nitrate-producing power of the soil, but this is not a purely chemical question, but a chemico-physico-biological one, and analysis can be of little help in such a question. Yet the determination of the total Nitrogen by the combustion process is of great value as giving some indication of the permanent value of the soil. It may be assumed, however that all except virgin soils are benefited by the application of soluble nitrogenous manures.

The percentage of N, P_2O_5 and K_2O in different manures can be judged from the following table:—

	N	P_2O_5	K_2O
(1) Ammonium Sulphate ...	20 %	Nil	Nil
(2) Sodium Nitrate ...	15½ „	Nil	Nil
(3) Potassium Nitrate (Crude) ...	2 to 13 „	Nil	7 to 40 %
(4) Street Sweepings	0 to ·5 „ (say ·25 „)	·25%	
(5) Fresh Cattle dung (ordinary cultivators') ...	·27 „ (Lime ·28%)	·18 „	·30 „
(6) Well-fed cattle dung ...	·35 „	14 „	·18 „
(7) Rotten farm yard manure ...	·9 „	·17 „	
(8) Cattle urine ...	·56 „	·02 „	1·13 „

		N		P_2O_5	K_2O
(9)	Poudrette (Poona)	·9 %		1 %	
(10)	Poudrette (Cawnpur) ...	·6 „		·5 „	
(11)	Sheep dung ...	·7 „		·5 „	
(12)	Fish manure ...	6·8 „		6 „	·7%
(13)	Bones ...	3·4 „	(Lime 28 „)	21 „	Trace
(14)	Dissolved bones	2·4 „	...	3 to 20 (soluble) 20 to 3 (insoluble)	Trace
(15)	Castor-cake (Bengal)	6 to 8 „ average 7 „	...	2·3 to 3·4 (average 2·9)	2·6%
(16)	*Til* cake ...	4·7 %		1·9 %	·9 „
(17)	*Mahua* cake ...	2·5 „		·93 „	
(18)	Safflower cake ...	5·8 „		1·9 „	
(19)	Earthnut cake ...	7·6 „		·9 „	·4 „
(20)	Cocoanut cake ...	4·5 „		1·5 „	
(21)	Poppy cake ...	7 „		3 „	
(22)	Decorticated cotton cake ...	6 to 7 „			
(23)	Rape cake ...	5½ „		1 „	
(24)	Linseed cake ...	4½ to 5 „			
(25)	*Kankar* ...	Nil	(Lime 50 to 80%)	Trace	Trace.

917. The amounts of Phosphoric acid, Nitrogen and Potash annually removed from one acre by various crops (bumper crops) are shown below.

Crops.	Grain.	Straw &c.	Chaff.	P_2O_5	N	K_2O
				lbs.	lbs.	lbs.
Rice ...	2,676 lbs. ...	2,676 lbs ...	...	16·3	26 2	28·1
Wheat ...	35 bushels=2100 lbs.	2,700 „ ...	300 lbs.	24	59	31
Barley ...	40 bushels=1920 „	2,300 „ ...	390 „	21	46	38
Oats ...	60 bushels=2400 „	2,900 „ ...	275 „	22	55	62
Maize ...	50 bushels=2800 „	4,100 „ ...	950 „ (cobbs).	31	67	80
Buck-wheat	30 bushels=1800 „	2,200 „ ...	...	30	35	9
Potato ...	200 bushels=5 tons	1,450 „ ... (haulms)	...	21	46	74
Beet ...	15½ tons ...	3 tons.	...	32	69	143
Mangel wurzel.	22 tons ...	6 tons.	...	46	150	264
Grass ...	...	2½ tons (dry hay)	...	23	83	85
Green maize (fodder).	...	11½ tons	...	46	85	164
Lucerne ...	...	8 tons (=2 tons dry hay)	...	26	113	71
Green sorghum.	...	15 tons	...	24	121	153
Sugar-cane	...	20 tons	...	15	153	44
Cotton ...	750 lbs. (seeds) ...	250 lbs (lint)	...	9	26	10
Tobacco ...	1600 „ (leaves) ...	1300 „ (stems &c.)	...	23	89	103
Cabbage ...	31 tons (heads only)	...	...	88	150	360
Onions ...	1¼ tons ...	...	...	37	72	72
Oranges ...	20,000 lbs. (fruits) ...	...	...	16	24	103

CHAPTER XCI.

CALCAREOUS MANURES.

MINERAL Sources.—Marble, chalk, dolomite and *kankar* (or *ghuting*) are the commonest minerals containing lime. Limestone rocks are rarely pure calcium carbonate ($CaCO_3$). They usually have some Magnesium Carbonate ($MgCO_3$), and also clay, silica, iron and organic substances, combined with them. When a limestone contains more than 23 per cent. of $MgCO_3$ it is called dolomite. When it contains fossil remains of animals, it has a certain proportion of $Ca_3P_2O_8$ combined with it. It occasionally occurs in a pure crystalline state, as calcite or calcspar. As stalactite and stalagmite it is found deposited in springs. Marble and chalk are also nearly pure $CaCO_3$. Limestones contain fossils more often than dolomites, and they are more easily scratched, and they effervesce more readily with hydrochloric acid. Limestones are found in all geological formations, as crystalline limestones and marbles in old formations, as chalk in the middle age of the geological era, and as *kankar* or limestone nodules in alluvial regions. Limestone rocks are often associated with gypsum, the former undergoing a local conversion in contact with decomposing iron pyrites (FeS_2). Where gypsum occurs, rock-salt may also occur.

919. Marble, dolomite and *kankar*, occur in almost all the districts of the Madras Presidency; in Khasia and Jaintia hills, in Assam; in the Sambalpur, Raipur, Jabbalpur, Nagpur and Wardha districts of the Central Provinces; in Kathiwar in the Bombay Presidency; and in Baroda, Hyderabad, Mysore, and Burma. Kathiwar marble is used even in Calcutta for building purposes. The best

limestones are found in the north of Jabbalpur and in the Vindhyan range. The Makrana marble quarries of Rajputana are very famous.

920. The production of marble in the Sonthal Parganas is about 7,000 tons per annum; in Monghyr, about 28,000 tons; in Mozufferpore, about 13,000 tons. Cuttack, Balasore and Manbhum also produce some. Singhbhum, Lohardaga and a few other western districts also contain limestone rocks. In Mozufferpore there are some *kankar* quarries also, the annual outturn of which is about 13,000 tons. In Monghyr the annual outturn of *kankar* is estimated at 28,000 tons and in Manbhum at 40,000 tons. *Kankar* lime is also produced largely in Cuttack, Balasore, Birbhum, Burdwan, Midnapur and Murshidabad.

921. Lime as a mere plant-food is not of much consequence, as every soil contains far more lime than can be used up by thousands of crops. As plant-food, shells and limestones rich in animal remains and containing $Ca_3P_2O_8$ and N, are better manures to use. In the district of Pertapgarh in Oudh, the cultivators use an ochry argillaceous *kankar* as manure. As plant-food this is a better substance to use than pure lime.

922. If a soil to the depth of 1 ft. weighs 3,250,000 lbs. per acre and if it contains only 1 per cent. of lime, it will have as much as 3,250 lbs. of this constituent. But a crop of 1200 lbs. of wheat and 2,000 lbs. of straw contains only 6 or 7 lbs. of lime, and of 600 lbs. of peas and 1200 lbs. of pea straw only 28 and 29 lbs. respectively. The farmyard manure returned to the soil, if properly rotten may contain as much as 2 per cent. of lime, *i.e.* if only one ton of rotten manure is applied per acre it would add 40 lbs. of lime to the soil, which is more than sufficient for the requirements of one single crop. 100 lbs. of bone-meal contains about 27 lbs. of lime, and 100 lbs. of crude gypsum refuse of soda water factories, as much as 30 lbs., quantities sufficient for supplying lime to almost any crop.

923. *Action of lime.*—It is not, however, by way of direct supply of food to plants that liming proves of benefit to the soil. Liming alters the texture of the soil either for good or for evil. In some soils it acts as a mortar and renders it hard, especially if slaked lime is applied as a thick, smooth paste on soil in hard condition. In other soils *e. g.* in peat, constant liming may interfere with capillary action by making the soil too open. Ordinarily, however, a soil rich in lime maintains a better capillary action, and liming improves the texture of soils by making them more porous. Lime exerts another kind of physical action which may be called flocculation, finer particles being converted into coarser ones. Schlœsing discovered that 2 parts of lime in the form of chloride, nitrate or sulphate of calcium immediately caused flocculation in 10,000 parts of a turbid liquor that contained a good deal of clay, that flocculation was perceptible when the proportion was reduced to 1 in 10,000, but that $\frac{1}{2}$ a part of lime had no effect on the liquor in question even in the course of 6 weeks. Another experiment may be tried to bring out the nature of the influence exerted by lime on plastic soils. Let a quantity of tough clay soil be worked into a plastic mass with water and let a portion be then dried, the result will be a mass of stony hardness. To another portion of the paste add half a per cent. of caustic lime and a diminution of plasticity will be obvious at once even when the mass is wet. On drying this mass will fall into crumbs at a mere touch. By liming, clay soils are made warmer, mellower, and of better tilth. This lightening effect lasts for years and is never entirely lost.

924. Another effect of lime is to set free for the use of crops, potash, ammonia and magnesia from hydrated double silicates. Experiments have shown that gypsum does this better than lime.

925. Lime in a caustic condition has a highly beneficial effect on peaty and boggy soils (*i. e.* soils rich in humus) and

on compost heaps. It hastens putrefactive processes and reduces vegetable substances into 'mould'.

926. When green—manuring is done, say, with *dhaincha* in August, liming is advisable to hasten putrefaction before the next crop, potatoes or sugar-cane, is sown.

927. Lime in the form of carbonate promotes the formation of nitrates in the soil. Slaked and hot lime destroy insects, and other vermins and also fungus pests. Liming of seed grain for preventing rust and smut is practised by European and American farmers. When any crop shows any fungoid disease lime should be scattered over it.

928. Poor sandy soils are also benefited by liming if it is done before the application of farmyard manure, in as much as it cements their particles together as mortar, making them stiffer and charging them with hydrous silicates and thus adding to their absorptive power. An admixture of carbonate of lime with soil increases its power to absorb and fix potash, soda, ammonia &c. from their solutions.

929. Liming corrects the acidity of sour land by neutralizing any excess of free humic acid.

930. Liming reduces the proportion of rushes and sedges and encourages the growth of good grasses and leguminous weeds in pasture lands.

931. But on poor soils liming should not be done. In fact, lime sets free such an amount of plant-food, that it gives immediate good return at the expense of the permanent fertility of the soil. There is a proverb which says, "Lime enriches the father but beggars the son." It is better to use ashes, bone-dust, apatite or gypsum when it is intended to supply lime to the soil.

932. Seeds and young plants should not be brought in close contact with lime, as the caustic action burns up seedlings. Grass can be actually killed by watering it with lime water.

933. The action of lime in decomposing orthoclase felspar has been already mentioned in connection with potash manures. Soils containing fragments of felspathic stone, therefore, are benefited by the application of lime.

934. Liming of the soil makes the crop earlier. Phosphates have a similar effect of hastening maturity of crops.

935. One or two tons per acre once in every 7 years is the best method of applying lime on lands suitable for liming. Lime has a tendency to sink gradually into soil ; hence the necessity of repeating the application from time to time. Generally speaking, calcareous regions are particularly fertile specially for pulse crops. Clay-soil rich in lime is fertile for most crops.

936. Soils are sometimes *marled i.e.* given a dose of clay containing 5 to 50 or even 80 per cent. of lime. The application of marl to sandy soils alters their texture for good. But marl must be found on the spot if it is to be economically applied. 70,000 or 80,000 lbs. per acre every 10 or 12 years is the rate at which marl is applied.

937. Lime exists in most soils in sufficient proportion, about $\frac{1}{2}$ per cent. of Silicate of Calcium being contained in most soils, the remainder, which is a more variable constituent, being $CaCO_3$. The presence of $CaCO_3$ in proportions of over 1 per cent. can be detected by the addition of any dilute acid which results in effervescence. Calcium silicate is much more insoluble, though it is of equal value with $CaCO_3$ when permanent fertility is taken into cosideration. Farmyard manure contains Ca chiefly in the soluble forms of sulphate and carbonate, but calcium silicate also occurs in minute proportions. Lime, Calcium hydrate ($CaH_2 2CO_3$) and Gypsum are readily soluble in water ; but *ghuting* and limestones ($CaCo_3$) are also soluble in water charged with CO_2. Rain water contains no lime, but well water and muddy canal or tank water contains 100 parts or over of lime in every

million parts, and clear canal and tank water slightly less, about 80 or 90 parts in million parts.

938. Unslaked lime (CaO) hastens the decomposition of organic matter, kills grubs and spores of fungi and decomposes double silicates, setting free the bases, potash &c. In poor soils the setting free of bases is not desirable, and, on the whole, slaked lime is to be preferred to hot lime, even when it is used as an insecticide and fungicide. Lime renders clays lighter and sands less dry. The presence of lime in soil is also useful for storing up phosphoric acid in seeds which occurs as $Ca_3P_2O_8$. It also neutralizes acids generally and precipitates oxalic acid in particular as oxallate of lime, which exercises useful functions in leaves and stems.

939. *Magnesia and soda.*—Magnesia replaces lime to a certain extent, and acts more or less in a similar manner in soils and in plants as lime does. Magnesia is also widely distributed in Indian soils and occurs chiefly as silicate.

940. Rain water which contains about 4 parts of N in every 10 million parts, contains no P_2O_5, K_2O, CaO, MgO or Na_2O. Clear canal water contains in 10 million parts about 2 parts of N, 10 parts of P_2O_5, 100 parts of K_2O, 900 parts of CaO, 700 parts of MgO, and 200 parts of Na_2O; while in a muddy state the proportions in 10 million parts would be —

N	...	...	4 parts
P_2O_5	...	...	20 parts
K_2O	...	...	200 parts
CaO	...	...	1,100 parts
MgO	...	...	1,000 parts
Na_2O	...	...	220 parts.

941. Well water which is known to be helpful to vegetation also contains a good deal of lime, *i.e.* about 1,000 parts in

10 million parts. The result of an actual analysis of a sample of well water is given below:—

N ...	... 150	parts in 10 million parts.
P_2O_5	... 100	„ „ „
K_2O	... 100	„ „ „
CaO	... 1,000	„ „ „
MgO	... 1,000	„ „ „
Na_2O	... 3,000	„ „ „

942. Well and canal water which are known to be harmful to vegetation, contain a larger excess of MgO and Na_2O, *i.e.* 6,000 or 7,000 parts of each in 10 million parts. Canal water rarely contains such excess, but well water often does. Hence the unsuitability of some well waters for irrigation and the belief current among Bengal cultivators of the general unsuitability of well water for irrigation.

CHAPTER XCII.

GYPSUM AND SALT.

GYPSUM occurs in the natural state in the following localities: at Trichinopoly, Nellore and Chingleput in Madras; in the latter two places as crystals of Selenite; in Cutch and the Kirtha range of Sind in Bombay; near Nagore in the Jodhpur State in Rajputana; at Bijawar and Baraundha in Central India; at Bannu and Kohat and the Salt Range in the Punjab; and in Kumaoun and Garhwal in the N.-W. P. Burnt gypsum is used as a cement. It is a valuable manure chiefly for leguminous plants, though it is not used in India. The Salt Range in the Punjab is overlaid by a deposit of gypsum 15 to 20 ft. thick, enough for supplying the needs of the whole world. The refuse from ærated water manufactories is artificial gypsum. It should be used mixed up with lime as it is liable

to contain an excess of acid. Calcined gypsum is Plaster of Paris which is used for making models and casts.

944. The effect of gypsum on *Usar* soil is very characteristic. If a good soil be mixed with a considerable volume of water and the muddy liquid be then poured over a filter, the water extract will come through rapidly. This, however, is not the case with *Usar* soil. An aqueous extract of *Usar* soils takes several hours or even days to pass through. The effect of small quantities of gypsum and some other salts, such as Calcium Chloride or Barium Chloride, added to the muddy mixture of *Usar* soil and water, is the curdling together of the soil particles, and the rendering of the soil more permeable. The Sodium Carbonate which is the most harmful substance present in *Usar* soil is also replaced by sodium sulphate which is less harmful.

945. Gypsum also exerts a powerful action in setting free potash which has been absorbed and fixed by the earth, that is to say, by double silicates in the earth. The CaO of the gypsum is fixed in the soil, while a corresponding quantity of K_2O goes into solution, as may be seen from the following equation :—

$$\left.\begin{matrix} Al_2O_3 \\ CaO \\ K_2O \\ H_2O \end{matrix}\right\} xSiO_2 + CaO, SO_3 = \left.\begin{matrix} Al_2O_3 \\ CaO \\ CaO \\ H_2O \end{matrix}\right\} xSiO_2 + K_2O, SO_3.$$

946. Gypsum sets free magnesia and ammonia in the same manner as potash, for the use of the crop. $MgSO_4$ acts in the same way as gypsum as a fertilizer.

947. Gypsum scattered on moist places in cow-houses and stables, does excellent service by checking the fermentation of urine and by absorbing some of the odours which arise from it. The ammonium sulphate produced by the addition of gypsum is a more non-volatile substance than the ammonium carbonate which is evolved from putrefying urine. The reaction is expressed by the following formula :—

$$(NH_4)_2 CO_3 + CaSO_4 = CaCO_3 + (NH_4)_2 SO_4.$$

948. The use of gypsum as a manure was known to the Greeks and Romans. It is largely used in Europe and America for manuring potatoes and clover. It is very desirable to extend the use of this substance for manure in India especially for clay soils. It benefits *arahar*, gram and other pulse crops, tobacco, rhea and potatoes. It should not be used annually, but once in 3 or 4 years, on the same soil at the rate of 5 to 10 mnds. per acre. It is a more useful manure than lime, the sulphur of $CaSO_4$ being also an essential constituent of plant-food.

949. *Salt.*—The chief native sources of common salt in India are, (1) the salt lakes and pits of Rajputana; (2) the salt mines of the Salt Range of the Punjab and (3) the sea and the estuaries.

950. The evaporation salt of Rajputana is derived from the Sambhar Lake, the Didwana Lake and the Pachbadra Pits. The Sambhar Lake is the most important of these three. It is situated on the borders of the Jaipur and Jodhpur States. It is a shallow sheet of water 20 miles long and 2 to 7 miles wide and only 1 to 4 ft. deep when full. The salt obtained is very pure and is largely used in the N.-W. P., Oudh, Rajputana and the C.P. The working season is between November and May. The lake is leased by Government from the Jaipur and Jodhpur States for Rs. 7,00,000, with, in addition, a royalty of 40 per cent. of the price of salt sold in excess of 63,135 tons, which adds the payment of about another two lakhs of rupees. There are 3 kinds of salt produced at Sambhar: (1) *Kyar*-salt, which is produced in permanently walled compartments within the lake whence soft earth is carefully removed and which are kept supplied with brine. (2) Pan-salt, which is produced in shallow basins along the shores, which are kept supplied with brine with hand-pumps or swing-baskets. (3) Lake-salt, which is formed spontaneously in the bed of the lake as the water evaporates.

951. The Pachbadra salt is procured from pits dug within what might be described as a former river-bed 6 miles in length by 2½ miles in width.

952. The rock-salt of Northern India is excavated chiefly from the salt mines of the Salt Range which extend for 152 miles from the Jhelam to the Indus. There are also salt mines in Kohat (trans-Indus) and the Himalayan salt mines of the Mandi State. The salt from these mines is obtained by pick and blast in the usual way with all mining operations. The supply is practically inexhaustible and the annual output is entirely dependent on demand. The salt is of very pure quality and it is a good substitute for Liverpool salt. The Mayo Mines of the Salt Range produce about 75,000 tons per annum.

953. Over a tract of country 15 sqr. miles in extent South-West of Delhi, salt is obtained from brine wells. This is known as Sultanpur Salt, which is somewhat bitter owing to the admixture of sodium sulphate. A poorer kind still is made at Sankaransar, 50 miles north of Bikanir. This is used for curing hides, for feeding cattle, and it is also eaten by the poorer classes. In Orissa there is a little salt manufactured under the Madras Salt Department. The sea-salt is manufactured chiefly in the Thana District of Bombay. The site chosen is usually on the shore of a creek or estuary, below the level of high tides and fully exposed to the influence of the prevailing winds. It is first surrounded by high embankments, the enclosed space being about 250 by 80 feet. The space so enclosed is then divided by other walls into 3 sections, the outer reservoir, the inner reservoir and the pan-area. The space devoted to pans is carefully levelled and a floor of clay repeatedly puddled until it becomes water-tight. The pans are formed by small clay partitions two feet broad which run the whole length and breadth of the pan-area, crossing each other at right angles and thus forming a

number of rectangular crystallising beds. The levels are so arranged that the water flows from the first reservoir into the second and from the second into the pans, being gradually concentrated as it flows from one basin to another. The water from the sea is admitted through a sluice and is thus exposed to evaporation till it forms brine. With this brine the pans are charged to a depth of an inch and a half, and within a few hours, in favourable weather, especially on shallow pans, a layer of crystals is formed, generally about one quarter of an inch in thickness. The salt is then racked on to ridges and left to dry and the pans are re-charged. Salt is manufactured in the East coast of the Madras Presidency also.

954. The total production of salt in India is about 1 million tons. Less than half this quantity is imported chiefly from Great Britain, Germany and Arabia.

955. As an article of food for man and beast, the value of salt is well known. As a manure, at the rate of 2 cwts. per acre, salt has been found useful for the following plants :—Cabbages, cauliflowers, beet, mangold, tomatoes, celery, horse-radish, onions, asparagus, cocoanut, date-palm, cashew-nuts, mangoes and bread fruit-tree. In reclaimed lands in the Sunderbans and elsewhere where the excess of sea-salt is too much for the healthy growth of ordinary crops those just mentioned may be successfully grown provided adequate provision is made for keeping out water from the field during the growth of the crops. Paddy seedlings grown on high land comparatively free from salt can be successfully transplanted and grown on lands containing an excess of salt. In certain soils, cereals, tobacco and cotton are considerably benefited by salt. Salt should not be applied when seed is germinating, as young plants and germinating seed are injured by the application. It may be ploughed in long before sowing or mixed with soil after the plants have grown a bit. It should

not be used as a top-dressing. The inferior kinds of salt are better for manurial purpose. Neither Na nor Cl is essential for plant life, and Na with S (*i. e.* Na_2SO_4) is therefore of more value as a manure. Impure salt contains also Na_2CO_3, $NaNO_3$, KNO_3 and other substances which are also useful as manure. NaCl has however an indirect manurial action on the soil, especially on soil rich in lime. As gypsum pushes out potash, magnesia and ammonia from the hydrous double silicates, so also common salt replaces lime first and then magnesia, potash and phosphoric acid. Wolff grew a quantity of buckwheat upon a field one half of which was manured heavily with common salt, while the other half was left unmanured. On analysing the ashes of the buckwheat straw, he found that the portion of the crop which had received the salt contained less soda but more potash, than the other. An application of common salt to the land might thus exert a decided fertilizing action, by merely pushing out lime and potash from the surface layers of the soil and sending them down to where the roots of the crop are. The disintegrating effect of lime and salt on rocks and soil particles is of great importance in the formation of soils and the growth of vegetation.

956. Salt is injurious to leguminous crops generally. To cereal crops it often does good, especially when there is any tendency for a crop running to straw and producing a small proportion of grain. It toughens the straw of cereals. Chloride of magnesium and chloride of potassium have the same effect of reducing the tendency of a crop running to straw. Tobacco grown with salt as manure produces tougher and more flexible leaves. Hemp produces a larger amount of better fibre with salt used as manure. Potatoes have a tendency to become waxy when salt is used as manure.

957. For cotton salt is a very useful manure on soils fairly rich in lime. It makes cotton bear longer in the

season, and stand drought better. It increases the quantity and improves the quality of lint.

958. As a germicide salt is a very useful manure for lands subject to rust and other fungoid diseases. 300 lbs. of salt and 200 lbs. of gypsum used per acre is an excellent preventive against rust.

959. Carbonate of soda which is formed by the addition of salt to soils rich in lime can dissolve to an appreciable extent phosphate of iron. This is another indirect fertilizing effect of the use of salt, on soils rich in lime.

960. The mechanical action of salt, like most other saline substances, in producing a good tilth in clay soils should also be taken into account. Granules of clay are flocculated or held together with salt even when it occurs in a minute proportion, and the soil is rendered more permeable to water and friable.

961. Air carries with it to long distances sprays from the sea and with rain we get more or less salt washed down into the soil. This is one source of salt in soils. As a general rule, the use of salt as a fertiliser is unnecessary, specially when the land is situated within 150 miles of the sea-coast.

962. The application of lime, gypsum and salt as manure if done at all should be done with care. It is rich soils only that can afford to part with large quantities of plant-food that are made available at once by such application. Where a soil is poor in potash and phosphoric acid, the application of lime, gypsum and salt, is altogether unadvisable. Clay soils rich in organic matter are particularly benefited by the application both mechanically and chemically, provided they are not already rich in salt also.

CHAPTER XCIII.

JADOO FIBRE.

BEFORE concluding the subject of manures, it will be well to mention a highly fertilizing general manure which goes by the name of 'Jadoo fibre,' *i.e.*, magic-fibre. The foundation of this fertilizer is absorbent peat-moss to which the following ingredients are added : soot, pink gypsum, dissolved bone-meal, nitrate of potash, soda and sugar, in various proportions, according to the crop to which it is to be applied. The manurial ingredients are first boiled with a sufficient quantity of water. The boiler is then filled with peat-moss in a dry state, and the whole is kept at boiling temperature for half an hour. The moss is then taken out and stacked; to it is added yeast, and the mass is kept fermenting for a month or six weeks in a moist state, after which it is fit for use. The boiled manurial substances without the peat-moss is called Jadoo liquid. Colonel Halford Thomson, F. R. H. S. of England is the inventor of Jadoo, and since its invention a Jadoo Company has come into existence and factories established in England, France and the U. S. A. The Philadelphia Company has arranged to turn out 8 tons of Jadoo fibre and 1000 gallons of Jadoo liquid per day. We might in this country try elephants' dung as the substratum in place of peat-moss.

964. The way Jadoo fibre acts is by encouraging the growth of surface roots without interfering with that of the tap-root. Having been subjected to boiling, all grubs and germs of parasites are destroyed, and being placed at the base of each plant soon after germination, it acts as a mulch and a protection against the attack of parasites, keeping the soil underneath moist and acting as a manure,

The use of Jadoo fibre cannot be recommended for ordinary agricultural crops but only for valuable fruit and flowering plants. A little Jadoo fibre pressed down at the base of a plant above and below the roots at transplanting will prevent its flagging. Seed, especially exotic seed, sown in soil made up of Jadoo fibre and earth, germinates beautifully. Some tea seed took 11 days germinating in Jadoo soil prepared in this way, while another quantity sown side by side in earth, took 37 days germinating. In the case of coffee seed, germination took place in half the time in Jadoo soil. For making grafts also, Jadoo fibre has been found very valuable. Peat moss being a very imperishable substance, it acts for a long time as medium of food-supply to the plant and it keeps improving the soil, making it more spongy but at the same time retentive of moisture.

965. Jadoo fibre can be used again and again for germinating seeds, &c. Renovation of used Jadoo fibre is done by exposure to air for a few days and moistening it afterwards with Jadoo liquid at a strength of 1 : 20 of water. The points specially to be noted in using Jadoo fibre are :—

(1) Thoroughly disintegrate the fibre before use, leaving no lumps. (2) Use it in a moist state. (3) In potting plants in Jadoo fibre, or Jadoo and soil, pot very firmly, more so than in ordinary soil. (4) Do not over-water plants growing in Jadoo fibre. Seed sown in Jadoo fibre usually need no watering after the first day when the fibre is moistened before use. (5) After sowing vegetable seed put about an inch of Jadoo fibre in the furrow in which you sow the seed. This will hasten germination, make the plants healthier and stronger, and bring the crop to maturity at least a fortnight sooner. Seed-potatoes should be sown in furrows with about 2 inches of Jadoo fibre.

PART V.

CATTLE.

CHAPTER XCIV.

BUFFALOES.

THE sub-family Bovinæ belonging to the tribe Ruminants is divided into three main groups: (1) the Bisontine to which belongs the yak of Central Asia; (2) the Taurine or oxen proper, subdivided again into (*a*) the *Zebus* (Bos Indicus) or humped oxen of India, (*b*) the *Taurus* (Bos Longifrons), the humpless cylindrical horned cattle of Europe, and (*c*) the *Gavæus*, humpless somewhat flattened horned cattle of India and South-Eastern Asia; and (3) the Bubaline comprising the wild and the domesticated buffaloes. These are the animals ordinarily known as cattle.

967. *Wild Buffaloes.*—The milk of the buffalo being twice as rich in butter as the milk of kine, buffaloes should be considered as a very valuable farm animal. In dry heat buffaloes are not so useful for draught purposes as oxen, but on the whole, they are superior cart and plough animals. Buffaloes are found in the wild state in the Himalayan Terai from Oudh to Bhutan and in the plains of Bengal as far west as Tirhut, but chiefly along the Brahmaputra, and in the Sundarbans. They also inhabit the table-lands of Central India as far south as the Godavery, also Ceylon, Burmah and the Malayan Peninsula. They live in the margins of forests rather than in the interior and they never ascend the moun-

tains but adhere to the swampy portions of the localities they inhabit. The wild buffalo is somewhat larger and plumper than the domesticated buffalo. In wild state they are very powerful but they are not savage nor unapproachable except where they are much hunted. They come to heat in Autumn, gestate for 10 months and produce their young in the hot weather. They usually live in herds.

968. *The domesticated buffalo* is also semi-aquatic in its habits. The female buffaloes breed first when they are 3 years old and then once in every 2 or 3 years only and produce 6 calves in all. Occasionally they calve annually. They continue to give 6 to 12 seers of milk for about 2 years after parturition. During the third year when they are in calf the yield of milk falls off until they cease giving milk altogether about 2 months before calving.

969. Buffaloes are *coarse feeders*, subsisting on stable litter and coarse grass, but buffaloes in milk should be given in the cold season (from November to March) 2 or 3 seers of oil-cake mixed with 10 seers of *bhusa* in the form of *sani* or *jab* in addition to grazing. In the hot weather, they should be given green fodder-plants finely chopped up with the *sani* unless there is plenty of pasturage. In the rainy season, they should get at the time of milking both in the morning and in the evening 4 seers of dry food consisting of wheat-bran and oil-cake, or barley, gram and wheat. Dry buffaloes and working buffaloes are left entirely on grazing.

970. The points of a good milking buffalo are: (1) Hind quarters, heavier than the fore quarters; (2) Skin, thin, smooth and shining; (3) Hair, fine; (4) Abdomen and udder, large: (5) Fine boned legs.

971. The points of a good working buffalo are: (1) Well-set, muscular, barrel-shaped form, heavier looking in front than behind; (2) Rough and bony quarters indicating strength; (3) Straight, strong-boned legs.

972. Buffaloes being slow in coming to heat, various devices are resorted to to bring them to heat. Flowers and leaves of *til*, about 2 ounces in weight, or anthers of *Kia* flowers (Pandanus Odoratissimus) given internally, are said to produce the effect. One buffalo bull is sufficient for a herd of 100 buffalo cows.

973. Male buffaloes are put to work at the age of three and they work efficiently for about 9 years afterwards.

974. The age of female buffaloes is determined by the number of rings on a horn. Each ring represents one year of age after the third year, that is, the age of an animal is the same as the number of rings on the horn *plus* three. The age of male buffaloes is usually determined by an examination of the teeth. They shed their first pair of temporary teeth when two years of age and they get all their permanent teeth when 5 years old, one pair being shed and replaced each year after the second year.

975. The chief diseases or complaints of buffaloes are the same as those of oxen, *viz.*, anthrax, quarter-ill, hove, foot-and-mouth disease, worm in the stomach and yoke gall. Worm in the stomach being more common among buffaloes than oxen, will be alone treated of here. This disease can be recognised by offensive smell of the dung, constant diarrhœa, loss of condition, and occasional escape of worms with fœces. The following vermifuge and purgative medicine has been found beneficial :—

Common Salt	...	....	...	½lb.
Fresh turmeric	...	...	...	¾lb.
Garlic ...	...	...	...	¼lb.
Old treacle	...	...	...	1lb.

This mixture is divided into 2 doses one being given in the morning and the other in the evening and its administration should be repeated for 3 or 4 days, if necessary. While

under treatment the animal should be given little water and made to live on dry *bhusa* as much as possible.

CHAPTER XCV.

OXEN.

THERE are three types of bovine cattle, —(*a*) draught animals, (*b*) milkers and (*c*) beef-producers. Draught animals cannot be good milkers or beef producers, though it is possible to have milking and beef producing qualities combined, as in the case of the Jersey cattle. But it is more satisfactory to keep the three types quite distinct and choose the best of each type for breeding purposes, the rest being sold by the breeder or used after castration. This system of breeding only from one type, tends to exaggerate the quality sought, which is either power of work and endurance, or quality and quantity of milk, or quality and quantity of beef. The Bankipore Cross-bred cattle established by one Mr. Tayler about the time of the Mutiny from the local breed crossed with English bulls, is a superior milker yielding from 8 to 20 srs. of milk *per diem*. A number of these may be made the basis for the milking strain. For power of muscle and bones and of action, the trotting bullocks of Nagpur come first, and a number of animals of this class may be made the basis of the draught strain. In Rajputana also there are very fine trotting bulls. There are no Indian cattle which produce the tasty beef which is obtained from the Highland Kylo, or the Dexter Kerry, and to establish both beef and milk producing strains, it is best to import both bulls and cows of the Kerry and the Jersey breeds from England and rear

them free from contamination with native breeds, on some hill station. The Jersey breed is specially mentioned as it comes from a fairly warm locality, is small in size, and is an excellent milking breed. The Ayrshire and Short-horn breeds though heavier milkers are not so suited for crossing with the smaller sized Bengal cattle, nor are they so adapted for the Indian climate as the Jersey cattle. Of the South-Indian breeds, may be mentioned also the Mysore cattle as a superior draught animal and the Nellore cattle as a superior milk-producing cattle. But they are large sized animals and heavy feeders and are not therefore recommended in the same way as the Bankipore cross-bred cattle and the Nagpur cattle as the basis of improvement in Bengal. The Kathiwar or Gir cattle are good both for draught and milk purposes and they are not so large as Mysore or Nellore cattle and may form the basis of selection for both types in Western India. His Highness the Gaekwar of Baroda has lately brought to the notice of the English public the excellence of this breed. The hill cattle are generally small in size, with undeveloped humps, but, as a rule, powerful. These and the Burmese cattle are the worst milkers. Of North-Indian cattle, the Hissar and Mewat breeds are the best for draught purposes, and the Hariana and Kosi breeds the best for milk. Sayad Mahammad Hadi, Asst. Director of Agriculture, N.-W. P. and Oudh, recommends the use of Kosi bulls for improving both draught and milking breeds. Kosi cows are small sized animals but they yield as much as 7 or 8 seers of milk per day. Some of the best milking cattle of Calcutta belong to this breed. Hundreds of cattle find their way annually from the Kosi fair to Calcutta. The excellent commissariat animals of Calcutta belong to the Hissar breed. Of Bengal cattle, the Sitamari breed alone may be mentioned as worth keeping up.

977. *Cross-breeding* with the Jersey may prove very beneficial to milkers, but, as a rule, cross-breeding with foreign cattle should be deprecated, as the native breeds are hardier

and less subject to diseases than cross-bred animals. As cows are carefully housed and treated, a certain amount of delicacy of constitution may not do much harm, but for draught animals, which must necessarily get rough treatment, delicacy of constitution is most undesirable. Draught animals should not be crossed with European cattle for another reason: the hump of the bullock is of great service in ploughing and in carting, and as European cattle are without humps the cross-bred animals are either with or without humps, or with ill-developed humps. We can leave beef-producing out of consideration altogether in a book on Indian Agriculture.

978. *Points.*—Of all pure-bred Indian cattle of Northern India which are easily available for breeding purposes for the other two types of animals, the Kosi is the best to select for Bengal. It is a native of Mathura in the N.-W. P. A good Kosi cow should be characterised by the following marks, which should characterize more or less all milch cows: —It should have a heavy dew-lap; a prominent forehead; *badami* (almond-shaped) eye; fine, glossy and polished hair; the hairy part of the tail should be bushy and tapery; the belly, large but well-proportioned to the size of the animal; the horns, elegant and well-proportioned; the udder, large, and front teats larger than the hind ones and all four well apart from one another. The milk-veins should be well developed and tortuous. The temper of a cow should be docile and the animal should be slow and lazy rather than sprightly. A bad tempered cow should be assumed to be a poor milker. Though a good milker is usually a good tempered animal, it should be also borne in mind that the better the cow the more likely she is to be of a nervous temperament and the more she is apt to be affected by a change in handling, milking or surroundings. If the new milker lacks experience, the result usually is a permanent shrinkage of the milk yield and early drying off of the cow. Heifers with their first calf should be milked for 10 or 11 months in the year, that the habit of

giving milk almost to the very end of the period of gestation may be established. If it is necessary to introduce a stranger let him begin milking and let the older attendant finish off. This should be continued for 2 or 3 days before the older attendant is allowed to be replaced altogether by the stranger.

979. A good Kosi bullock has the following characteristic marks, which should characterize more or less all bullocks. The hoofs should be dark, round and compact, *i.e.*, the toes not too far separated from each other. The eyes should be dark and prominent, not unlike the eyes of a deer. The forehead should be prominent. The muscles on the top of the neck are well developed, giving a greater width to the upper surface and forming a channel when the neck is bent down. Animals which show a thin upper neck and no channel should be considered weak. The chest should be broad, the tail thin and the sheath not too prominent. Grey is the best colour for bullocks as it denotes strength. If a bullock is white, its hump should be black. Black and white are the best colours for cows. A cow should be thin at its neck and slight at fore-quarters and heavy and deep behind ; while a bullock should be well-proportioned, heavier, in fact, at the neck and fore-quarter than behind. Both cows and bullocks should be good eaters.

980. *Breeding.*– Cattle should not be allowed full liberty in breeding. Bulls should be prevented from breeding for the first three years of their life and heifers for the first two years and a half. Calves should be given plenty to eat if they are to turn out good breeding animals. Neglecting calves is a great mistake. Some cows calve annually and some once in two years, and occasionally once in three years. Those that calve once a year should have the bull put to them 2 months after calving. Those calving once in two years should have the bull 8 months after calving. If a cow after giving birth to its first calf does not show a desire for the bull by coming to heat within 4 months after calving, it should be taken as one

which will not calve every year. Those calving annually give the normal quantity of milk for the first 4 months and those calving once in 2 years for the first 8 months. After this period the quantity of milk decreases gradually but the quality improves until shortly before they go dry when the milk becomes somewhat saline in taste, and a cow which gives such milk is called *khero* (*i.e.* saline). The *Ek-barsi* goes dry in 8 months and the *Do-barsi* in 12 to 14 months after calving. There are some cows, however, which give milk for a longer period. The milking period depends chiefly on the breed also on feeding.

981. *Telegony and Atavism.*—*Telegony* is a distinct impression of the first impregnation on the future progeny of the same dam. By continuous breeding the distinctive features of the original sire are gradually reduced, though they may never absolutely disappear. Telegony is distinct from *atavism* which is also reversion to some original type. Atavism may take place along the male or the female line of descent, the balance depending upon whichsoever parent possesses the greater prepotency, the result of pedigreeing. Telegony is a reversion only to an original sire.

982. The *period of gestation* of a cow is 283 to 300 days, of a buffalo 315 to 350 days, of sheep or goat 148 to 156 days and of a sow 120 to 127 days. A cow goes on calving from the 3rd to the 20th year of her age. Cows come to heat once in 3 weeks until they get pregnant.

983. To ascertain whether a cow is pregnant or not, it is milked separately and a drop of the milk is taken out of the pail with a bit of straw and dropped on a glass of clean water. If the drop of milk sinks to the bottom, without much dispersion, the cow is pregnant; if it disperses readily in the water, the cow is not pregnant. Our *Gowalas* usually judge pregnancy by the following sign: if the animal habitually stands with its tail removed on one side from the vulva, it is pregnant, if it habitually rests its tail on

the vulva, it is not pregnant. Bellowing or absence of bellowing, jumping or walking quietly, and the tri-weekly œstrual sign, are other indications.

984. The following food produces the effect of exciting the desire of the cow for the bull : a daily ration of *Juar* fodder with 2 to 4 lbs. of boiled cotton seed. This food given for 3 or 4 weeks produces the effect. A heifer which refuses to take the bull may be converted into a *Kamdhenu* (or virgin milker) if she is milked regularly. At first she will yield very little milk, but if the milking is persisted in, she gives considerable quantities, *i. e.*, 2 to 3 seers a day, and the milking can be done at any time of the day.

985. Cows in calf which have got dry are usually given no special food but simply left to graze and drink what water they can get. But some nourishing food and plenty of good drinking water should always be provided for cows in calf, though fattening a cow in calf is highly undesirable. Half a seer of oil-cake or cotton-seed mixed up with a basketful of *bhusa* or fodder grass or leaves (*e. g. baer* leaves) should be given as *sani* every night, in addition to grazing. A few days before delivery, they should be given ½ a seer of boiled barley mixed with 1 *pow* of *gur* and ½ a *pow* of mustard or linseed oil and ½ a *chittack* of common salt every day. This mixture is a mild laxative but strengthening food and it is also beneficial in helping on the flow of milk. After delivery liquid food should be avoided as much as possible for 4 or 5 days and the cow kept on such dry food as wheat-straw, wheat-bran, *gur*, fenugreek, ginger and oil. After 4 or 5 days the colostrum gives place to the flow of true milk. The colostrum has aperient property and it is useful in relieving the calf of the mœconium or the accumulated fætal dung. After the period of colostrum has passed the cow should get for a month 1 seer of boiled wheat (or mixed rice and *kalai*) mixed with 1 *pow* of *gur* and the milk left by the calf which is drawn, besides grazing *ad lib.* This mixture is very helpful in

inducing the flow of milk. The first three weeks' milk inducing diarrhœa among children, is usually rejected, *i. e.* given to calves and cows, or pigs, or utilized for making butter. For the first three weeks after calving a cow is called *kechute* (or green). There is usually a new accession to the flow of milk about the 21st day after calving. If at this time or soon afterwards, the cow is sold to a new owner or removed from one place to another, there is a serious interruption in the flow. This should therefore be regarded as the critical period as far as the yield of milk is concerned, and very careful feeding and treatment must be resorted to and on no account should the attendant be changed at this period. If it is necessary to sell or remove the animal, this should be done before the 20th day, after calving, or 3 or 4 months after calving.

986. The following foods are helpful in enhancing the quantity and quality of milk:—

(1) 2 seers of boiled *másh kalai*, 1 seer of crushed *juar* and 5 seers of *ghol* (buttered milk or churned curd) made into a gruel, in addition to grazing.

(2) Husked *dál* of gram well steeped in water, in addition to grazing.

(3) Cyamopsis psoroiloides cut green before the formation of seed, in addition to ordinary grazing.

(4) Grazing early in the morning *i. e.*, from 2 A. M. when there is plenty of dew on the grass, in addition to ordinary grazing.

(5) Dried leaves or green twigs of wild plum (*baer*) chopped up into small bits given with cotton seed, in addition to ordinary grazing.

(6) *Kanta-notea*, bael fruit and *másh kalai* boiled together in water given in addition to grazing.

(7) Silage and bran (say 20 lbs. + 4 lbs.).

(8) For a large sized cow yielding 12 to 15 seers of milk a day, a very economical mixture is for each feed, 5 seers of

chaff, 1 seer of molasses and 24 seers of water, given twice a day. The following mixture is also very good :—1 seer of oil-cake soaked in hot water, with 5 seers of chaff and a handful of salt, twice a day.

987. A liberal supply of *good drinking water* is necessary if good flow of milk is desired. Cows do not drink the same quantity of water at all seasons. If they are given watery or sloppy food they require less water. A middle sized cow should be provided with 10 gallons of water per day, though she may not drink it all. One part of dry food to 4 of water is the proportion in England, but here they require more water.

988. The flow of milk is also enhanced by rubbing the udder with castor-oil after each milking, supplemented, of course, by proper feeding. Quick milking also excites the milk-glands more than slow milking and an expert milker who can do the work quickly can always get more milk out of a cow than a slow milker.

989. Milking 4 times a day instead of twice increases the quantity of the milk, but the quality is somewhat inferior. It is always desirable, however, to milk cattle thoroughly and not to spare any milk for calves. Thorough milking not only gives one the last strippings which are richer, but it tends to increase the flow of milk and enlarge the size of the mammary glands. The septum of the mammary glands is along the median line and milking should be done first at one side and then at the other and not, as is sometimes done, at the front teats first and hind teats afterwards.

990. The *calves* are allowed for one month to suck as much milk as they can while they learn to pick up a few blades of grass. But after a month restriction should be put on the calf and it should be hand-fed with a mixture of *ghol*, and barley, or with wheat-meal and linseed-meal, and allowed to pick up grass and other fodder plants. They should be kept as much apart from their dams as possible. Hand-feeding should be practised when the calf is only a week old *i. e.*,

immediately after the colostrum period. In 3 months the calf learns to live on grass chiefly, getting a little *bhusa* and oil-cake in the form of *sani* in the evening, say 2 seers a day, up to an age of 6 months, after which if there is good pasture no special feeding is required.

991. *Working bullocks* should get as *sani*, straw and *bhusa* (½ a maund to 30 srs. per day, according to size) and ½ a seer to 1 seer of oil-cake or 1½ to 2 seers of cotton seed per day; but if there is plenty of herbage, 5 to 10 srs. of straw and 1 seer of oil-cake or cotton seed are sufficient.

992. *Sudden changes* of food are injurious for all classes of animals. Boiled food, linseed and carrots are recommended for debilitated animals.

993. *Relative value of food-stuffs.*—One hundred pounds of good hay (8th) are equal to

(1st.) 28 lbs. of beans.
(2nd.) 37 lbs. of peas.
(3rd.) 43 lbs. of linseed cake.
(4th.) 44½ lbs. of wheat.
(5th.) 59 lbs. of oats.
(6th.) 62 lbs of maize.
(7th.) 90 lbs. of lucerne.
(9th.) 317 lbs. of oat-straw.
(10th.) 350 lbs. of potatoes.
(11th.) 360 lbs. of guinea grass.
(12th.) 370 lbs. of carrots.
(13th.) 370 lbs. of mangold.
(14th.) 469 lbs. of turnips.
(15th.) 670 lbs. of beet.

994. *Preparation.*—Crushing of gram, oats &c.; boiling in the case of *Urd* and *Kulthi*; parching of barley and wheat, and grinding of maize, bean &c., are the preparations necessary. Bran should form part of the food of all animals, but used in large quantities, it has a tendency to produce calculi.

For cattle, straw should be cut long and not short, as is done for horses.

995. *Relation of food to weight.*—There are cows and cows, and there are bullocks and bullocks. A cow weighing only 300 lbs. as our Bengal cows often do, should not be given the same quantity of food as a cow weighing 1500 lbs. or 1700 lbs. as some of the Dutch cows weigh. The world's champion cow of the present time is the Holstein cow, Rosa Bonheur V, an animal actually weighing 1750 lbs. and eating daily 174 lbs. of food (of which 52·43 lbs. is dry matter), consisting of 114 lbs. of silage, 12 lbs. of maize-meal, 9 lbs. of oat-meal, 3 lbs. of bran, 9 lbs. of oil-cake, and 27 lbs. of roots. She actually gave during a show-test, 106·75 lbs. of milk in one day, and 726·25 lbs. in one week. Although we can never expect a Bengal cow to weigh over 21 mnds., eat over 2 mnds. of food every day, and give 50 seers of milk a day, yet we can judge from this case what the proportions should be in the case of a first class cow receiving first class treatment. The proportion of food in the case of a cow in full milk should be $\frac{1}{10}$th of its weight, of which the dry matter should be a little less than $\frac{1}{3}$rd and it should give $\frac{1}{20}$th of its weight in milk when in full milk. In warm climate the proportion of dry matter may be $\frac{1}{4}$th or less.

996. *Housing.*—Bullocks, cows and calves should be all kept in-doors during the cold and wet seasons, in a well ventilated house but protected from draughts. The other points to be considered in housing cattle are :—(1) 500 to 700 cub. ft. of space for each adult animal according to size and a minimum floor apace of 50 sqr. ft. should be allowed. (2) There should be sufficient light and ventilation without draught,—the openings being high up. (3) An impervious floor. (4) Plentiful supply of pure water not only for drinking but also for flushing, the daily allowance being 10 gallons per head. (5) A proper wide and shallow drain (3 ″deep) along the middle of the cow-house, the cattle standing back to back

on the two sides of the drain. (6, The manure pit should be at a sufficient distance from the cow-house,—60 to 100 ft. away, if possible. The criterion for judging the sanitary state of a cow-house or bullock-shed is *sweetness*. If it smells sweet, the sanitary arrangement is all right ; if it smells offensive, it is not all right.

997. *Bulls* are not given any special food but they usually live on the fat of the land by sheer force, being surrounded by a halo of religious sanctity. They need not get any better food than bullocks and they should be kept with bullocks and given light work, and allowed to breed when required after they are 3 years old. They should be allowed to breed only up to the 6th year of their age.

998. *Age.*—The age of cattle is determined by looking at their teeth. They have 8 incisor teeth all placed at the lower jaw there being no teeth on the upper jaw, which is provided with a 'dental pad.' Up to the age of 2½ they are milk-teeth. Between the age of 2½ and 3 the middle pair falls off and is replaced by a permanent pair. Between the age of 3 and 3½, or at most 4, the 2nd pair is replaced, and in the beginning of the 5th year the 3rd pair is replaced. The fourth pair is replaced similarly towards the end of the 5th year, when all the permanent teeth are complete. After this there is no definite means of determining age from teeth. The wearing of the teeth gives some indication of age but after the 6th year age must be determined by looking at the rings on the horns. This is not a very satisfactory method either. In the case of a cow, each ring is taken to denote one calving.

999. *Castration.*—Castration should be performed in winter on animals about 2½ years old. If they are castrated early, the operation is easier but the animal loses all spirit and courage and becomes very feminine, while its neck becomes thin which is very objectionable for draught purposes. Castration by crushing or hammering with a wooden mallet

without opening the scrotum is usually practised in this country. This method is, however, not always successful and it is better to open the scrotum and remove the testicles completely with a knife or better still with Kendall's Emasculator which grinds the spermatic cord and blood vessels instead of cutting them. It is said that daily application of salt to the testicles of calves, inducing mothers to lick the part hard, results in gradual loss of genital functions. This, however, needs confirmation by repeated experiments. Boiled ghee and carbolic acid (20 : 1) should be rubbed daily at the wound after an animal has been castrated.

1,000. *Docility*.—Good treatment and constant handling by persons from early age are the best means of making animals docile. Castration is practised to bring about docility. As an important accessory to rational methods of securing docility of cattle may be also mentioned dehorning.

1,001. *Dehorning*.—When the horns are just budding in the calf, the hair should be clipped from the skin all round and the little horn moistened with water to which a few drops of ammonia have been added to dissolve the secretion of the skin, that the potash subsequently applied may adhere to the surface of the horn. The skin is not to be moistened except on the horn where the potash is to be applied. A stick of caustic potash is then held and one end of it dipped in water until it is slightly softened. It is then rubbed on the horn. The operation is to be repeated 5 to 8 times until the surface of the horn becomes a little sensitive. Only a scale will be formed, but no inflammation or suppuration of the part, if the operation is carefully performed. There are hornless breeds of cattle which, if otherwise useful, may be selected for breeding.

1,002. *Summary*.—In rearing cattle, specially for dairy purposes, three things should be constantly kept in mind; *viz*., Breed, Feed and Trouble. By breed is meant undoubted pedigree, *i.e*., both the sire and the dam should be known for

2 or 3 generations past to have been of the desired type. In arranging for the feed of cattle, paddocks with shady trees are a *sine qua non*. *Juar*, *kurti*, millets, *khesari* and other cheap grains, bran and oil-cakes are the principal food-stuffs, besides straw, that should be depended upon. The oil-cake should be bought but the other things should be grown, if possible, on the premises. Good water is of first consideration.

1,003. Under the head of trouble comes changing of litter or bedding, keeping the house clean, avoiding all ailments by watching the progress of the cattle day by day. If they go off their feed or cease to ruminate, disease should be inferred. Negligent milking and neglect of sanitary conditions generally, in the dairy, may result not only in diseases of animals, but the diseases may be communicated to human beings. Tuberculosis, scarlatina, typhoid fever, diptheria, cholera, *Cholera infantum*, and other diseases in the human subject have been traced to infected milk. Scrupulous cleanliness in every detail is needed, especially in dairy management. One man should be employed for looking after and milking only 8 to 10 cows. Mismanagement must take place if one man has to look after a large number of dairy cows.

CHAPTER XCVI.

GOAT-KEEPING.

GOATS will eat almost anything and no fodder crops need be grown for them if there is enough of jungle land at one's disposal. It is easy to maintain 10 or 12 goats on the pasture which is required for one cow. Jungle or hill land

is best cleaned by having 2 or 3 goats per acre maintained on it. They should be kept within barbed wire hurdle fence 4 ft. high to keep them from doing mischief to plantations. They can be kept day and night out, except in the rainy season, when shelter should be provided. Goat's milk being richer than cow's milk and being more easily digested by invalids and children, goat-farming should not be despised as an accessory to dairy-farming. Cow's milk contains about 4 per cent. of fat, 4 per cent. of casein and 4 per cent. of milk-sugar; while goat's milk, 7¼ per cent. of fat, 5 per cent. of casein and 5 per cent. of sugar, and about 4 per cent. less water. Cream cheeses from goat's milk are excellent. A goat may be bought for a Rupee in some mofussil places, and the skin (weighing, say, 4 lbs.) afterwards can be sold for a Rupee or even more. All milking goats should be given some gram or pulse to eat, say ½ a lb. to 1 lb. daily, besides coarse herbage. Angoras are the most famous milking goats and their wool is almost as soft as silk. The fleece of each Angora goat (about 3 lbs. per annum) would bring enough of income to pay for the keep of the animal.

CHAPTER XCVII.

CALCULATION OF WEIGHT OF LIVESTOCK.

ASCERTAIN the girth in inches at the back of the shoulders, and the length in inches from the square of the buttock to a point even with the point of the shoulder blades. Multiply the girth by the length and divide the product by 144, which gives the measure in superficial feet. Then multiply the superficial feet by the number of pounds per foot for cattle of different girths, the product of which

will be the number of pounds of beef, veal, pork, or mutton, in the four quarters of the animal.

1,006. For cattle of a girth of from 5 to 7 feet, 23 lbs. may be calculated for each superficial foot, and for a girth of from 7 to 9 ft., 31 lbs. to the superficial foot. For sheep, goat and calves, of a girth of from 3 to 5 ft. the yield should be taken to be 16 lbs. per sqr. ft., and of a girth of less than 3 ft., 11 lbs. to the sqr. ft. When an animal is but half fattened a deduction of 14 in every 280 lbs. or 1 stone in 20 stones should be made; but if the animal is very fat 1 stone for every 20 should be added.

1,007. Suppose it is desired to ascertain the weight of the meat of an ox whose girth is 6 ft. 4 in. and length 5 ft. 3 inches.

$$76 \text{ inches} \times 63 \text{ inches} = 4788 \text{ square inches.}$$

$$4788 \div 144 = 33{\cdot}25 \text{ sqr. ft.}$$

Multiply this by 23 and you get 764·75 lbs. or 54$\frac{4}{7}$ stone as the weight of meat. The deduction or addition, as the case may be, should then be made, if the animal is too lean or too fat.

CHAPTER XCVIII.

POULTRY-KEEPING.

THOUGH this subject cannot be included under agriculture proper, farmers should keep poultry for hurdling in in their fields, as they are excellent scratchers of ploughed up land from which they pick up grubs of injurious and other insects. A few short notes on poultry-keeping will not, therefore, be out of place.

(1) Keep one variety only of fowls or ducks. For fowls the real Chittagong is the best for Bengal, as foreign varieties

do not stand the climate well. The full grown Chittagong fowls weigh on the average 8 *seers* and the eggs 1½ to 2 ozs. each, if the fowls are kept in a healthy manner. Aylesbury ducks and Muscovies or Musk ducks do well in Bengal and either of these varieties may be selected. Their average weight is also about 8 *seers*.

(2) A breed that produces the largest number of eggs is not necessarily the best. The eggs of such a breed are small, and a very small proportion of them hatch out. Some hens would lay as many as 200 eggs in the year, while others would lay only 30 or 40. Hens that lay only about 10 eggs before becoming 'broody' and breed only three times in the year, generally incubate and hatch into life every chicken out of their eggs. These are the best hens for breeding and for use as foster-mothers.

(3) Incubation and bringing up eggs artificially can be done in patent Incubators and Foster-mothers. Tamlin's Nonpareil Incubator, for 200 egg size, costs £7·5, and Tamlin's Nonpareil Foster mother, 100 chick size, costs £3·12 (W. Tamlin, Richmond, Surrey, England).

(4) Poultry-keeping can never be entrusted to servants. Personal attention of the owner or a member of his family is essential.

(5) The fowl-house where hens roost and lay eggs must be perfectly weather proof and yet well ventilated. It must be cleaned out daily and ashes (and occasionally lime) spread on it afterwards. If a wooden house is specially constructed, the construction of too large a house where a great many fowls may be kept, should be avoided. It is best to keep half a dozen birds (say five hens and one cock) in each house or coop 5 ft. square and sloping from 6 to 8 ft. in height. There should be a perch 18 inches from the ground and 4 inches in diameter for all the six birds to roost on. A pole of *garan* wood answers very well. This should be placed in the front part of the house, that the hens may lay eggs

on nests of straw at the back of the house. There should be a large sized window in each house.

(6) The yard in front of the fowl house should be covered in the rainy season, as wet is most injurious to fowls. At other seasons a covered run is not needed, and it is good to let the fowls go about in the open as much as possible, and scratch the loose earth of the yard and pick up and swallow bits of grit or bones, which is their natural habit. As the yard gets polluted in time with the dung of the fowl, it is necessary to clean it from time to time, say once a week, and sprinkle ashes over it, and a layer of dry earth 2 inches deep twice a year.

(7) A shed open in front should be provided for the sitting hens.

(8) The whole *i. e.*, the roosting and laying houses, the covered and open runs and the shed for sitting hens should be fenced in to a height of 6 ft. with wire netting of 2-inch mesh.

(9) The *points* of a good bird are : (1) it should be young *i.e.*, it should show smooth and not rough and horny shanks ; (2) it should be of a good size ; (3) it should be plump and sprightly looking ; (4) the legs should be short ; (5) the breasts should be full. Village stock prove healthier than town-stock and on no account should Calcutta Municipal Market birds be chosen as the basis of a breeding stock.

(10) The stock should be always kept young, and all birds more than 2 years old should be used up or sold.

(11) No fixed scale of feeding can be recommended. If hurdling in of poultry by rotation in fallow land and ploughed up land, be systematically practised, very little feeding will be needed. But the rule to be observed in feeding fowls is to give them as much paddy, buck-wheat, oats, or barley, as they will *eagerly* eat. but no more, so that very soon after the feeding is over, no grains should be seen on the ground, and yet there should be no eagerness noticeable on the part

of the fowls to have more grains. Birds kept enclosed in fowl-house and yards should have three meals a day; others, one or two according to the circumstances. Very healthy village fowls pick up all their food themselves and they are not fed. The morning feed should be of a soft nature, such as rice-dust (*kunra*) and water, or cooked rice and *dál*, and the evening meal should consist only of dry grain. A seasoning of salt and pepper to the morning meal of mash, or rice and *dál*, keeps the fowls in very good condition. The rejections from the kitchen or the table make excellent morning feed for fowls. The best grain to use for the evening meal is buck-wheat, which has the effect of stimulating the egg-laying power of hens and ducks. There should be plenty of grass in the yard where birds have their run, as they are benefited by liberal grazing. But if the supply of grass is scanty, the fowls and ducks must be supplied with green food, such as cabbage or carrot leaves &c.

(12) Fowls must never be left without a constant supply of good drinking water which they may drink at their pleasure. When any epidemic such as fowl-cholera (*Guti*) is raging, the vessel of water should have a few grains of powdered sulphate of iron mixed with it, enough to give a very slight metallic taste to the water. This is an excellent way of preventing *guti*.

(13) The eggs should be collected from each fowl-house twice a day.

(14) Not counting the chickens that are hatched out of eggs, each fowl-house with five hens in it, should produce 500 eggs per annum. If these can be sold for 100 annas or Rs. 6-14 as., the birds should pay for their keeping. But if they have to be fed altogether with purchased food, three times a day, it does not pay keeping fowls, unless one goes in for breeding high class fowls, which should be the aim of the owner from the very first.

(15) Eggs should be brooded in as fresh a state as pos-

sible; but they can be collected and kept for a week before they are put to brooding, without any harm occurring. Eggs which are very stale, *i.e.*, set more than a week after they are laid, even when they do hatch, produce sickly birds.

(16) Shallow *gámlás* make very good brooding nests. Three such *gámlás* are sufficient for three brooding hens kept in a five feet square shed with a small yard in front, situated in a damp place. Coolness of shed and dampness of atmosphere are helpful to the chickens hatching out more easily; but draughts and rain must be avoided. Over the *gámlás* should be put some ashes, then some fresh cut damp grass, and on the top a layer of straw cut up in lengths of about 2 inches. 10 to 12 fowl eggs and 6 to 8 duck's eggs, are quite sufficient for each hen.

(17) Brooding hens must be fed twice a day, and it may be necessary to lift them up with their wings and bring them down from their *gámlás* to the food and water supplied to them. Should any eggs be found broken by some accident, it must be removed, fresh straw put on, and any eggs found soiled must be cleaned with salt water, and dried immediately afterwards and replaced in the nest. The breast of the hen should be also cleaned, if it is found soiled in any way before she is allowed to go back to her *gámlá*.

(18) In the brooding shed there must be a heap of sand and ashes where the hens may have their daily dust-bath which keeps them free from lice. Half an hour should be quite enough for the feeding, recreation and dust-bath, after which she must be encouraged to go back to her nest, which she usually does with alacrity. But one or even two hours' absence of hen from her nest does not interfere with the hatching of the eggs.

(19) The chickens come out after 21 day's incubation. For a whole day after hatching they require no food, and as some eggs are a few hours later than others in hatching it is

best to let the mother come out with all her chicks before any attempt is made to feed them.

(20) The best food for newly hatched chickens is hard-boiled yolk of eggs mixed up with stale bread moistened with milk. This may be given with some barley and water for the hen, that the hen and the chickens may eat together. The hen with the newly hatched chickens should be kept in a separate coop. A big basket with open lattice work which is ordinarily used in this country answers very well, as it can be placed on grass and moved about from time to time. After the first day or two, ground oats or buck-wheat, also some finely minced meat, should be given to the chickens, while the hen may be given the same food in a coarser state. Hourly feeding of chickens is necessary for one week, after which the feeding should be done less often ; but the secret of success in poultry-keeping consists in feeding the chickens often and with fresh food. Potatoes mashed with bran and finely chopped up green grass, is a very good food for chickens after the first week. They must have a supply of good water also. After four months, the best birds being reserved for breeding, the rest should be sold or converted for table use. More substantial pens or coops should be provided for chickens when they are a month old.

(21) *Preserving eggs.*—Eggs can be preserved in a fresh state for eating, in a solution of Silicate of soda (called also water-glass). One volume of the semi-fluid silicate should be mixed up with 20 volumes of water and the fresh eggs pickled in this solution will last several months. Before cooking a puncture is to be made in each egg to avoid spurting and bursting. To preserve 600 eggs, 6 lbs. of water-glass dissolved in 8 gallons of water are sufficient. The exact procedure to be followed is this :—Each time 25 to 30 fresh and uncracked eggs are taken, placed in a sieve, and dripped with warm melted lard. The eggs are then removed from the sieve and when the

coating of lard has cooled they are submerged in the above solution of water-glass.

1,009. Another method of preserving eggs has been also successfully followed. Eggs are placed for 5 minutes in a 20 per cent. solution of sulphate of iron to which is added 1½ per cent. of tannin soluble in water. The eggs are then rinsed in water, dried and kept as ordinary eggs are kept.

CHAPTER XCIX.

DISEASES OF CATTLE.

THE commonest diseases of cattle are Anthrax, Quarter-ill, Foot-and-Mouth Disease, Pleuro-Pneumonia, Hoven, Constipation or Impaction of the rumen, Dyspepsia, Debility, Catarrh, Jaundice, Worm in the Eye, Red Water, Apthae, Abortion and Bloody Milk. Worm in the stomach has been already dealt with. In connection with this subject the reader should study the chapter on Agricultural Bacteriology in Part VI. of this book. Of the cattle diseases mentioned, the first four are due to pathogenic organisms, and certain general ideas regarding the manner in which such diseases spread and are arrested both in animals and in plants should enable the reader to apply remedies intelligently in particular cases.

1,011. All that the agriculturist is expected to do is to render *first aid* in the case of serious ailments, and treat all ordinary ailments of cattle. For special diseases special remedies have been found beneficial, and some of these are given below.

1,012. *Anthrax* (*guti*).—Preventive inoculation should be resorted to, if possible. When disease has appeared careful

treatment does good in some cases. When the purging and passing of blood and mucus continues for more than 24 hours, the following mixture is said to give beneficial result :

Camphor	...	¾ tolah.
Saltpetre	...	¾ ,,
Dhutura seeds	...	¼ kanchha.
Chiretta	...	¾ tolah.
Country spirit	...	2 chhitaks.

When diarrhœa has gone on for much longer than 24 hours, ¾ tolah of Gallnuts, finely powdered should be added to the above mixture.

1,013. The diet should consist of rice and *Kalai* gruel well boiled and of thick consistency, to which should be added some *gur* and salt. Water should be given at the first stage of the disease when there is costiveness, heat and discharge of mucus from mouth and nostrils, but when diarrhœa sets in, the animal should not be allowed to drink any water. No straw or other fibrous food should be given.

1,014. If the animal lives for 8 or 9 days and gets little pustules on the body, it generally recovers.

1,015. *Small-pox proper* in cattle is not known as *guti*, but as *Besherá*. It occurs as pustules on the teats and udder. It is a harmless disease. Some inconvenience is felt at the time of milking but that is all. Application of carbolic oil (1 : 40) or butter, is all that is required by way of treatment.

1,016. *Inoculation.*—According to Koch, immunity from rinderpest is conferred on cattle after a sub-cutaneous injection of 10 c. c. of bile taken from the gall-bladder of an animal which has succumbed to a virulent attack of rinderpest. This immunity sets in on the 10th day at the latest and is of such an extent that even 4 weeks afterwards 40 c. c. of rinderpest blood could be injected without any injurious result. By mixing virulent rinderpest blood-serum

with rinderpest bile Koch got the important result of being able to immunise animals with 5 c. c. of bile mixed with 5 c. c. of the blood-serum. An admixture of rinderpest blood with rinderpest bile, even increases the immunising qualities of the latter. Blood-serum itself has a little immunising property, but this immunity lasts only for a short period. For protective inoculation on a large scale, a mixture of an immunised animal's blood-serum and virulent rinderpest blood was found by Koch to be of great value. To prepare this serum, the blood is taken from the jugular vein and conveyed into an air-tight bottle and allowed to remain for 24 hours in a place kept as cool as possible and not disturbed. The fibrin and serum will be then found to have formed.

1,017. The following paragraphs on the "Serum simultaneous method" of inoculation are taken from a report of Dr. Lingard, Imperial Bacteriologist, dated 5th January 1901:—

"*Serum Simultaneous method.*—This method, which has been very widely adopted in South Africa with most encouraging results, consists in injecting a small dose of protective serum on one side of the animal's body and at the same time a small dose of virulent rinderpest blood on the opposite side. A mild form of the disease is produced in 90 per cent. of the animals, with a loss of only one-half per cent. and with the production of a permanent immunity, while the other 10 per cent. are also protected for some months even though they fail to react to the inoculation. In this connection I would point out that when a totally unprotected animal is sub-cutaneously inoculated with the most virulent blood, it shows no symptoms of disease previous to the 3rd, 4th or 5th day following inoculation and then only does the temperature begin to rise. It is not until at least three days later *viz.*, the 6th, 7th to 8th day that any symptoms of rinderpest become manifest. Therefore in practical field-inoculations it has to be first ascertained whether the disease is already

incubating in the animals about to be inoculated, as in such cases the simultaneous method of inoculation should not be employed, but serum alone injected in large quantities should diarrhœa not yet have supervened. If this latter symptom should have already made its appearance nothing can save the affected animal.

"*Experiments in the Laboratory.*—The experiments carried out with the above mentioned method in this Laboratory prove that the animals which show temperature reactions with fairly marked symptoms are immune for upwards of one year, and there is no reason to doubt that it will last for a much longer time, if not for the life of the animals. On the other hand, the animals showing no temperature reaction or symptoms of the disease, partly due to the large doses of serum used, may wear off their immunity earlier than those which reacted to the simultaneous method, and this difficulty can be got over by re-inoculating those animals, which have not reacted within a week or ten days of the simultaneous injection, with a second dose of from 1 to 10 c. c. of virulent blood.

"*Results in field inoculations.*—The inoculations carried out by the serum manufactured at this Laboratory in Bareilly, Aligarh, Bulandshahr, and Dehra districts gave eminently successful results, and Mr. Holmes in his report from Madras states: 'Out of 339 bullocks inoculated, nine died, but these deaths were attributed to old age and debilitated conditions, and to the fact that the animals were suffering from rinderpest previous to inoculation. I do not consider that any of the deaths occurred as a direct result of inoculation. I think it is safe to say that, as a result of these inoculations, rinderpest was at once checked and a heavy loss averted among the cattle.'

"By referring to Table C of the Assistant to the Inspector General, Civil Veterinary Department's Annual report for the year 1899-1900, we find that out of 1,730

animals inoculated by the above method, only three died after inoculation.

"*Hill cattle.*—There is a great difference in the dose of serum required for the inoculation of *hill cattle*, as compared with that which is safe in plain animals. Notwithstanding that the serum simultaneous method by itself has not been found to be reliable in this particular breed, yet on re-inoculating these animals with from 1 to 10 c. c. of virulent blood during the seven or eight days following the injection by the simultaneous method, protection has been brought about and an active immunity conferred.

"*Serum alone.*—The use of serum alone causes no reactionary fever and it affords immediate full immunity and is very useful in the case of dairy animals and pregnant cows, where it is desirable that the milk supply should not be interfered with, and no cases of abortion take place. The temporary immunity given by injecting with serum alone is sufficient to protect the animals throughout an outbreak. The experiments carried out at Mukhtesar proved that the animals injected with 10, 20, 50, 100, and 150 c. c. per 600 lbs. body weight, were found immune on the 43rd, 76th, 103rd and 164th days, respectively, after serum injections, and in each case when tested by the introduction of virulent blood sub-cutaneously, only a slight temperature reaction followed, clearly showing that the animals submitted to the above test were perfectly protected and would remain so for a much longer period than those stated above.

"*Manufacture of serum.*—During the year 1900, 464,765 c c. of protective rinderpest serum were produced at Mukhtesar, and 119,880 c. c. have been issued to the Veterinary Superintendents, etc, of different provinces in India. At the present time we have 33,673 doses tested and ready for despatch on receipt of a telegram, but in addition some 50,000 doses are already in stock and only require testing, a matter of two weeks' duration. The manufacture

of rinderpest protective serum will be continued at the Imperial Bacteriological Laboratory, and a depôt might be opened in the North-Western Provinces, as has been arranged for by Government for the supply of the Bombay, Bengal, and other Provinces, so that the serum may be readily obtained when required."

1,018. *Foot-and-mouth disease* (*khurá*).—Keep the parts clean and repeat disinfecting applications. One part of carbolic acid mixed with forty parts of cocoanut or other oil is the best thing to apply to the sores of the feet. In the absence of carbolic acid, camphor (1 ounce) mixed with a pint of oil may be used. Solution of alum (10 grains to an ounce of water) is the best thing to use for washing the mouth. Bran-mash, rice gruel and salt are the best food substances to use.

1,019. *Hoven.*—Starved cattle suddenly pasturing on luxuriant herbage, get hove, hoven or tympanites. Puncturing the rumen is the handiest remedy and it gives instant relief. Murshidabad *gowálás* actually practice puncturing of the rumen in hoven. If an eight-inch trocar and canula are available it is of course much better to use these than a knife. The puncture should be made in the left side at a point equally distant from the point of the hip and the last rib. The canula is left until all the gas has escaped. Linseed oil with a few drops of carbolic acid or oil of turpentine mixed with it may be given afterwards. Rubbing the stomach and dashing cold water on it and walking the animal constantly are also beneficial if the owner does not venture on puncturing the stomach.

1,020. *Quarter-ill or galaphula.*—When a case of this deadly disease occurs in a herd, the pasture must be changed at once. The disease runs a very short course, proving generally fatal within 24 hours. Blistering of the neck is practised by *gowalas*, but it does not seem to do any good. Preventive inoculation is effective but it has not been

introduced as yet into India. Horses are more subject to it than cattle. This disease is usually mistaken for anthrax, in this country.

1,021. *Pleuro-Pneumonia.*—Contagious Pleuro-Pneumonia so dreaded in Europe and so fatal, is supposed to occur in the Punjab and Sind. Slaughtering the affected animals and segregating those free from disease are the only remedies that are in use.

1,022. *Cyst disease.*—Cyst Disease caused by the immature Tænia echinococcus, a worm which in its mature condition is harboured by dogs, is pretty common, affecting the liver, lungs and spleen of cattle. Tape-worm in man is caused by this parasite. Exclusion of dogs from cattle-shed and clean food and drink are the preventive measures that can be adopted.

1,023. *Impaction of the Rumen.*—This is usually caused by the animal eating greedily too much of a palatable but dry food, *e. g.*, grain or bran, and when it gets very little water to drink. A strong dose of purgative medicine and a stiff dose of country spirit in warm water should be given. The belly should be hand-rubbed and the animal made to walk. The animal should be given as much tepid water or gruel as it will swallow.

1,024. *Red water or bloody urine.*—It usually occurs after parturition. Poor and coarse food is supposed to cause this disease. It is ushered in by diarrhœa but constipation sets in afterwards when the urine becomes claret coloured and the animal evinces pain in voiding it. The urine is also offensive in odour. The animal becomes weak and debilitated. Death may take place in 5 days or in 20 or 25 days.

1,025. Purgative medicine, rice gruel, soft green grass, country spirit, pure air and clean surroundings, prove beneficial.

1,026. *Diarrhœa.*—Calves often suffer from diarrhœa. Lime water, country spirit and catechu are beneficial. Pow-

dered chalk and cinnamon are highly beneficial both in dysentery and in diarrhœa to bigger animals as also to calves.

1,027. *Mammites* caused by cold, injury to teats, over distention of udder, or early weaning of calf, is to be treated by fomentation, gently drawing out of milk and gently rubbing the udder after each fomentation with salad oil or cocoanut oil. A purgative medicine (linseed oil or sulphate of magnesia) also helps. If abscess forms, lancing and poulticing will be necessary.

1,028. *Bloody milk.*—The *gowalas'* remedy for this abnormality is very successful. He feeds the cow with plenty of salt, *i. e.*, seven times exactly in one day.

1,029. *Abortion.*—Abortion is due either to disease, or to external injury, or to predisposition to abortion. Abortion is catching, in some cases. The animal should be segregated from other animals in calf, and kept in perfect rest, the loins and haunches being covered with cloth dipped in cold water and wrung out. Hot drinks should not be given, but the animal kept on light and green food.

1,030. *Warts.*—These are removed by rubbing on them warm bullock's blood for 2 or 3 days. Warts on chicken's face are cured by dipping their head in urine for 3 or 4 days successively.

1,031. *Yoke-galls and sores.*—When fresh, use brine and give the animals rest from work. If after 5 or 6 days' application no benefit is derived, use the following ointment:—

Sapheda (crude carbonate of lead of *bazaar*) ½ lb. boiled with ½ lb. of cocoanut oil and well mixed together by stirring. When boiling bring down, add ½ ounce of turpentine oil and keep the ointment corked up in a bottle and apply daily until the sore is healed. Another mixture which has been found highly beneficial is hog's lard with powdered turmeric (unboiled turmeric being used).

1,032. For *cuts*, apply mustard oil at once as a stiptic, and antiseptic, then apply either Vaseline or hog's lard.

Apthæ (*chhâru*).—Powdered round pepper and salt should be rubbed on the tongue, as deep as possible, when an animal goes off feed from this cause and begins to salivate. Another remedy successfully applied by *gowálás* is letting the affected animal lick a basket rubbed over with a mixture of turmeric and salt.

CHAPTER C.

THE THEORY OF HEALTH IN RELATION TO FOODS AND FODDERS.

THE food or fodder should contain all the constituents in their proper proportions for the building up of animal tissues. Animal tissues again are all built or formed out of blood, and blood is therefore the life or vital fluid, which it should be the object of food to keep in proper condition. Blood is not a formed, but it is the ultimate formative, tissue of all animals including man. It is a highly complex fluid and it is greatly influenced by surrounding conditions. It circulates through a perfectly germ-proof channel and unless there are sores on the skin or in the alimentary canal which serve as open doors of access of pathogenic germs, it is not so susceptible to get diseased as one might think looking only to the fact of the highly nourishing properties of the fluid for those germs which surround us even in the healthiest climates.

1,034. Blood consists of fluids and solids which should be kept at a definite proportion if health is to be maintained. Some departure from this proportion is constantly occurring and must occur; but a persistent and excessive departure from this proportion is the predisposing cause of most diseases whether they are due to pathogenic organisms or not. Even anthrax and anthracoid diseases need a certain

vitiated character of the blood as their predisposing cause, as every animal does not run the same risk of attack, and when attacked, the same risk of falling a victim to them.

1,035. The proportion of water in blood should vary from 800 to 900 parts in 1000 parts. If the water is less in proportion the blood owing to its thickness is sluggish in its flow. A certain state of fluidity is also necessary to keep those salts, *e.g.*, phosphates of lime and magnesia, in a soluble condition, which are required to be absorbed and assimilated into the system. Salts must be in a soluble condition to be absorbed and excreted by glands, and a deficiency of water in blood results in such diseases as gravels of uric acid or oxallate of lime in the kidney or bladder.

1,036. Besides water, food supplies to the blood, fats, starch and sugar, by which the fatty tissues of the body are nourished and by which also materials for respiration and production of heat are supplied.

1,037. The solid portion of blood consists of white (leucocytes) and red blood corpuscles. White blood corpuscles are larger, irregular in shape, endowed with amœboid movements; while the red corpuscles are smaller and devoid of the power of movement. The white blood corpuscles have a special connection with health. They attack any foreign substances, such as bacteria, that may invade the blood and destroy them by digesting them and ejecting the undigested residue into the blood. Wherever a wound occurs the white corpuscles rush into the breach, preserve the tissue from the attack of injurious organisms, break up and remove the accumulated red corpuscles and gradually help to fill up the breach. The red corpuscles have also an important function to perform, as it is by their means that oxygen is conveyed to the various tissues, which burn up the excess of hydro-carbons and carbohydrates, thus simultaneously keeping up animal heat and getting rid to a large extent of useless substances. The actual agent which conveys the oxygen is iron to which also

the red colour of the corpuscles is due. An adequate supply of iron with the food is therefore necessary to keep the blood in health. Where there is deficiency of iron in the food the blood becomes veinous or dark in character and loses the bright arterial scarlet appearance.

1,038. Many physiologists recognise the existence in the blood of a third corpuscle which they call the *hæmatoblast* or blood-former. The hæmatoblast is supposed to give rise to leucocytes and the leucocytes to the red corpuscles.

1,039. The serum or fluid portion of the blood contains two substances called respectively fibrinogen and fibrinoplastin. When blood is let out it co-agulates, the co-agulation being due to a ferment acting on fibrinogen and fibrinoplastin, which convert them from a fluid to a solid state.

1,040. An excess of water in the food results, on the other hand, in the colouring matter of the red corpuscles being partly washed out and the white corpuscles also getting macerated. The turgidity of the capillaries resulting from excessive absorption of water, leads to their walls getting weakened and their vitality lowered. Serum escapes from the capillaries, which are so weakened, into the tissues and cavities of the body. Anœmia and dropsy may follow a protracted course of feeding with an excess of succulent food. Repletion and congestion of important organs are frequently caused by an excessive draught of water, specially when the system is in too heated a condition. Giving of water to horses and other animals after work when by perspiration the blood has become thick, is the right plan, but when the heating of the system is excessive and circulation very rapid, a draught of water often results in congestion of lungs or of some other organ. A middle course, therefore, is advisable, *i. e.*, in too heated a condition an animal must be allowed to cool down a little by gentle walking or by wisping, before water is given to it; but if the work has not been of a violent but of a light character, giving of water

immediately after work relieves the blood of excessive thickening and consequent sluggishness, while it does no harm.

1,041. Proteids should also be given in certain definite proportions to different animals. They are necessary for the formation of muscles, and blood-serum is the vehicle by which the proteids of food find their way into the various tissues. Febrile diseases result in excessive using up or cumbustion of proteids. Hence the need of foods rich in proteid matter, such as milk, soup, carrots, grass, bran mashes and linseed and other gruels, during and after febrile attacks. An excess of proteids, on the other hand, produces congestion which results in local inflammations, and susceptibility to pathogenic diseases, as the bacteria find a suitable nutrient soil in blood containing an excess of albuminoids.

1,042. Fat is also burnt up largely in wasting diseases, and as fat is necessary in the respiratory process for the production of heat and animal vitality, its repair by means of proper carbonaceous food is necessary. All the muscular tissues are more or less associated with fat which makes them pliant, and joint-oil or sinovia is necessary to prevent concussion between bony surfaces. Where fat is present the combustion of muscular tissue does not take place to any appreciable extent for the respiratory function. Hence the presence of fat saves the muscular tissues from oxidation or burning. On the other hand, an excess of carbonaceous or fatty food, results in debility and interference with the vital activity of the cells of the body, and comparative stagnation of the circulatory system. If such food is persisted in infiltration of fat takes place inside the tissues of important organs, and finally fatty degeneration or actual conversion of these tissues into lumps of fat.

1,043. What has been said about a due proportion being observed in the various constituents of food, such as water, albuminoids, and carbonaceous food, holds equally true as

regards the various salts required for the building up of the animal tissues. Sodium chloride, for instance, is absolutely necessary for the preservation of health. It is needed for the formation of blood, of gastric juice and of bile, and for the digestion of albumen. The salt taste of perspiration and tears is a proof of its presence in the blood. A salt lick should be provided in every cow-house and stable. But excess of common salt is very injurious to the animal system, producing various skin diseases. Dogs fed on highly salted food are particularly subject to eczema; and scurvy in man is due to the same cause.

1,044. Similarly, a certain amount of *potash* is needed by the animal, and the favourite food of farm-animals, *viz.*, grass and other green herbs, is rich in potash. Deficiency of potash means impaired tissue nutrition; but excess also is highly injurious; as it induces an excessive fluidity of the blood and consequent increased activity of the kidneys. If food too rich in potash is persisted in, serum may flow from capillaries into the surrounding cavities and tissues, resulting in dropsy. The extra work thrown on the kidney results in their ultimate derangement and disease. Blood also gets poorer in albuminoid matters, *i.e.*, in fibrinogen and fibrinoplastin, and as a consequence skin eruptions follow. Chlorate of potash so changes the colouring matter of the blood, as to render it useless as a vehicle of oxygen.

1,045. Phosphates are absolutely necessary for the formation of bones and teeth, and if they are not supplied with food in sufficient quantities bone-softening or rickets follow, and a tendency to fracture of bones. The teeth also develope slowly and they tend to decay. Decayed teeth are very common among animals reared on poor pastures. Nerve and brain substances also require a supply of phosphorus for their proper nutriment. On the other hand, an excess of phosphatic diet results in the breaking up of blood corpuscles, in fatty degeneration of the walls of blood-vessels and of the liver.

Like potash, phosphorus has also the tendency to render proteids more liquid in character than in their natural state. The blood becomes thinner and it has the tendency of flowing out from the capillaries into surrounding tissues and cavities. Thus greater work is thrown on the kidneys. Albumen, and broken up red corpuscles with their colouring matter pass out with urine. Pastures manured with superphosphate of lime have been observed to give rise to such urinary diseases to animals.

1,046. Iron which is necessary to keep the blood and the liver in a healthy condition, when ingested in excess gives rise to hyperæmia, a condition which is opposite to that of anæmia. Inflammations may result from hyperæmia, as from excess of albuminoids in the blood.

1,047. Carbon dioxide gas renders the blood dark and displaces oxygen. But as oxygen is easily replaced when it is again supplied it has no permanent ill effect on the blood. But carbon monoxide while it heightens the colour of blood into bright red, brings about such a change in the condition of the iron as effectually to prevent re-oxidation. Hence the poisoning effect of carbon monoxide gas and the blood-stained urine we sometimes see passed by animals which have been exposed to the influence of this gas in burning stables and cowsheds.

1,048. To illustrate the effect of certain substances on urine it may be sufficient to cite the following additional examples :— (1) If one puts his feet into a solution of potash or soda these salts can be detected in a short time in the urine. (2) If turpentine is rubbed into the skin it is detected in the urine in a very short time by the odour of the sweet scented violet which it imparts to that fluid. (3) Diabetes in horse and sheep has been noticed as being due to mouldy bad foods, by mow-burnt hay and grass, or hay grown with excessive quantity of nitrate of soda.

1,049. The class of diseases produced by *food containing*

too much moisture, such as *bil*-grass &c., are those in which lowered vitality and debility with dropsies occur, such as, water-braxy, shell sickness, and trembles. Low temperature and exposure to cold, winds and rain aggravate these diseases. Moisture within, moisture without, moisture above below and around, must dilute and impoverish the blood and macerate and soften the tissues, disintegrate the cell elements and render them incapable of performing the functions of organic life, and affect the blood cells and the walls of the blood vessels injuriously. Hence the necessity of giving plenty of straw and other dry and also nourishing food in the rains and in the early part of the cold weather.

1,050. *Foods too rich in carbohydrates and fat* produce liver disorders and diarrhœa. The blood becomes overladen with their products, and highly plastic, from imperfect oxidation, congestion being the result.

1,051. *Foods too rich in proteids* produce extravasation of blood into the tissues resulting in inflammations and red-braxy. Milk containing a large amount of proteid matter is a suitable food for young animals, but when it is excessively poor or excessively rich, calves and other young animals suffer from different forms of disease. Milk is again a conveyor of germs and various deliterious matters. Vegetable mineral and animal poisons and diseases such as anthrax may be communicated through the vehicle of milk from one animal to another. In the artificial rearing of calves, skim-milk mixed with lime-water, is often found a more suitable nourishment than the rich milk as it comes from the cows' udder.

1,052. *Innutritious food* results (1) in indigestion, as animals require a larger quantity of it to get the requisite amount of nourishment or a quantity which taxes the strength of the digestive organs; (2) in debility for want of sufficient nutrition.

1,053. *Dirty foods*, such as grass full of sand &c. are injurious, as the sand or dirt has the tendency to collect in the

Cœcal and other pouches of the stomach producing irritation, inflammation, ulceration and colic.

1,054. *Frosted food* has a tendency to cause abortion, but there is no fear from this in the climate of Bengal.

1,055. *Decomposing mouldy and decayed* foods are the most injurious of all, as they are liable to cause septic inflammation of the stomach and bowels, and produce diarrhœa and even blood poisoning. Moulds, that is fungi, sometimes cause abortion.

1,056. *Impure water* is the most fruitful cause of diarrhœa and dysentery.

CHAPTER CI.

UTILITY OF GROWING FODDER CROPS.

IT is often said, there is no practical advantage in growing fodder crops, that the raiyat will never take to them, and that it is only the cattle of experimental farms and those belonging to some dairy farmers or *gowálás* which are fed on fodder crops, the majority of the cattle of the country living on the herbage they can pick up and the straw harvested with the grain crops. That the majority of the cattle of Bengal at least look very miserable, is admitted, but it is said they are hardy and efficient. There is no doubt the native cattle stand the climate better than foreign cattle, which degenerate very rapidly imported into the climate of Bengal, which are the first to succumb when there is any epidemic about, and which are more subject to diseases. But this is due to the indigenous cattle being thoroughly acclimatised and not to their being lean or half-starved. Even in Bengal some cattle are better than others and the better class, which

are generally owned by substantial carters, who feed them fairly well, work much better than the leaner sorts. The improvement of draught-cattle, not only in appearance but also in physique, must be effected not by going in for importing new breeds, but by feeding the existing acclimatized breeds better than they are at present fed. A man who owns 5 acres of land must have a pair of oxen to work it. At the rate of half a maund of fresh grass per day, the two animals require an annual supply of 365 maunds of fodder. This quantity of ordinary grass is the produce of about 4 acres of land, but a *raiyat* who owns a holding of 5 acres cannot set apart 4 acres for the feed of his cattle. The remaining one acre will not support himself and his family. Nor has he now the same facilities for pasturing his cattle on waste land and forest land which he had at one time when there was far less land under cultivation. True, he has the straw, both cereal and leguminous, from his five acres to feed his bullocks, and the scanty herbage of his fields after a crop has been harvested and until a new crop is put in. But from 5 acres of land the quantity of straw and herbage at the dry season, obtainable, is only about 150 maunds. When the full quantity needed is 365 maunds, 150 maunds must necessarily keep the animals only half-fed or still worse. No wonder, the raiyat's cattle are so miserable. Where waste lands and forest lands are abundant, the question of growing fodder crops may be of no importance, but for most parts of Bengal the question is most important. 365 maunds of fodder can be grown on one acre of land by proper cultivation and proper choice of staples. There are certain fodder crops that will grow both in the *kharif* and *rabi* seasons; others are perennial (such as Panicum muticum and lucerne). Leguminous fodder crops are more nourishing than cereal straw or grasses; and a portion of the fodder say, one-fourth, should be of a leguminous kind, so that the proper albuminoid ratio (1:12 or 1:13) may be secured without the addition

of oil-cakes. Of course, for enriching fields the purchase of oil-cakes is always advisable, as the dung is richer when the cattle are fed on oil-cakes. But for the purpose of feeding cattle alone the purchase of oil-cakes is not necessary, if three parts of the fodder used consist of graminaceous kinds and one part of leguminous kinds.

1,058. It may be said,—why not do away with cattle altogether, if to feed a yoke of oxen on natural pasture, the cultivator must set apart 4 acres of land, when the average holding of a cultivator is only 5 acres? It is just possible theoretically for "every rood of land to maintain its man," *i.e.*, for one acre of land to maintain a family of 4 or 5 members, also for a man with the help of his wife and one or two fairly grown up children, to cultivate one acre of land with such hand-tools as spade, hand-hoe &c. But it is only by dint of hard and steady labour distributed over the whole year that a man can with hand-labour only, get sufficient food for himself and his family out of one acre of land. A family of 4 or 5 members may be regarded as consisting of $2\frac{1}{2}$ adult units each requiring 6 maunds of food grains for sustenance, or 15 maunds in all. An acre of land produces ordinarily about 15 to 20 maunds of grain,—partly cereals and partly pulses. At times, it so happens, that cultivators are compelled owing to the wholesale death of cattle caused by famine or rinderpest, to have recourse to spade cultivation. They are then able, by dint of hard labour, distributed throughout the year to cultivate only about 1 acre per family and just keep themselves alive. But it so happens in this country that each family has allotted to it an average quantity of 5 to 6 acres of land, and it is possible with lighter labour (with the assistance of cattle) for the family to earn a good deal more than bare living. By the help of fodder crops, one can not only grow crops for home consumption and sale, but also keep his cattle in good condition, in which case they can render more efficient help to his cultivation than they could otherwise do. The import-

ance of growing fodder crops on one-fifth or one-sixth of his holding, should be impressed upon each cultivator through educational and other means.

CHAPTER CII.

FODDER CROPS.

GROWING of fodder crop is not unknown among Indian dairy men, but there is no arrangement anywhere for growing fodder all the year round and cultivators generally leave their cattle to pick up what they can get. There are few plants that would not be eaten by cattle. Where grass is scarce they are fed on the leaves of *bur*, peepul, *baer, figs, pakur*, mango, jack, *sajna, bael, simul* and other trees. In times of great scarcity even date-palm leaves are given chopped up to cattle. Ordinarily, cattle would not eat *neem* and *sorguja* leaves, but they have been seen to eat even these when they can get nothing else. But because they will eat almost any kind of plant it is not to be supposed that all plants afford an equally nourishing fodder, or that no special arrangement is necessary for growing food for cattle. Plants that yield specially nourishing fodder will be now described. In Bengal there are some crops grown for fodder. When there is little pasturage available, dairymen give their milch cows country peas, leaves and pods of *babul* trees, pods of *sirisha* tree (Mimosa sirissa), *bhringi* (Phaseolus aconitifolia) and sorghum vulgare *(gama)*. To stimulate the flow of milk *gowálás* give their cattle a food made by boiling together slices of unripe *bael* fruits, *mas-kalai* and *kanta-notia* (Amaranthus spinosus). *Gowálás* are also aware of the fact

that cows yield more milk if they get to eat *simul* flower (Bombax heptophylla), or seed and plants of cotton. It is also well known in this country that skins and rinds of sweet fruits *e.g.*, mangoes, jack,&c., the water strained out after boiling rice, rice-dust (*khud*), husk and bran (*bhusa*) also *mahua* flower (Bassia latifolia), *gur* and common salt, are stimulating food for cattle. So special arrangements for feeding cattle are not unknown in this country.

1,060. Introduction of new fodder crops is however desirable. The value of *sun-flower* as a fodder has been already referred to. *Field-beans* form a principal staple of English agriculture, as they yield the most nourishing food for animals. The dwarf shrub of field-beans produces an abundance of pods. Bean-meal is the favourite food for horses, cattle and sheep. It is more strengthening than wheat and barley and yet it does not cause diarrhœa. In fact, in diarrhœa bean-meal is freely used as a binding food. In p. 589 we have placed beans first in the list in considering the *relative value of food-stuffs*. If field-beans are not grown we can at least grow popat-bean and cow-peas more largely. In some parts of Bengal, field beans, though an exotic, used to be grown as a crop in former years, and there is no reason why its cultivation should not be revived. In the district of Murshidabad field-bean plants are met with in the wild state in nearly every old garden. Gardeners of Murshidabad call the plants baklá and they remember the days when it used to be grown as a crop for the Commissariat Department, when soldiers were stationed in that district.

1,061. A sweet root, called the *mangold* or mangel-wurzel, which is much larger in size than beet but allied to it, is used extensively as a fodder crop, in England. Larger varieties of turnip, carrot, cabbages are also used as fodder. Salt is used as a stimulating manure for these crops. In the Sunderbans and other parts of the country where the soil contains an excess of salt, waste land can be profitably utilised in

growing these crops for rearing live-stock in a systematic manner.

1,062. *Reana Luxurians* or *Euchlæna Luxurians* (buffalo-grass) is a huge kind of grass eagerly eaten by cattle of all kinds. It grows taller than sorghum and it tillers much better, but it must be grown on rich soil, and there must be facility for irrigation if it is to be successfully cultivated all the year round. Nine or ten months after sowing, the plants come to maturity and run to seed. It should be cut as fodder before seeding *i.e.*, when it is still tender. Grown on rich soil and constantly irrigated each clump will send out 80 to 90 shoots 10 to 12 cubits high, capable of being cut 7 to 8 times in the year, each cutting yielding from 50 to 60 maunds of green food per acre. It grows most luxuriantly at the Sibpur Farm,—at least, as well as *Juar*, and cattle eat the stalks of Reana with greater relish than they do of *juar*. Sown in May, one heavy crop of fodder can be had in September witout irrigation.

1,063. Besides sorghum and reana, may be mentioned another rank-growing annual grass, which is actually grown along with *aman* paddy in some districts of Bengal, where it is known as *Erá-kati* (Ischæmum rugosum, *i.e.* No. 22 of the list given in p. 197). The introduction of Paspalum dilatatum is also being urged by the Agricultural and Horticultural Society of India.

1,064. Of rank-growing grasses, which are either perennial, or practically perennial, *i.e.*, which once grown occupy the soil always as a weed, may be mentioned the following which are liked by cattle: Guinea grass (Panicum Jumentorum), Para grass or *Latá* grass (Panicum muticum) and sorghum halipense. *Latá* grass grows equally well on dry land and in shallow water.

1,065. *Guinea grass.*—Its special excellence consists in its being perennial. The stumps can be removed with the roots and planted elsewhere, and the plantation thus indefinitely extend-

ed. For this crop, rich soil and facility for irrigation are essential. The land should be also well-drained, that water may not lodge in it even in the rainy season. If the plants are grown from seed, the land should be prepared when the rainy season is not quite over; but if they are grown from root-cuttings the land should be cultivated in March or April, soon after the winter crop has been harvested, irrigation being done, if necessary, to soften the soil for convenience of cultivation. After ploughing, the land should be cleaned of weeds and straw by passing the ladder or harrow over it. Before June the land should be got thoroughly clean and ready by 7 or 8 ploughings followed by as many ladderings or harrowings. Manure should then be spread over the land and ploughed in and as soon as the rains have commenced the planting of stumps should begin. If the plants are grown from seed, a seed-bed is necessary. Holes should be made in the seed-bed and two seeds put in each hole in regular lines and the bed again levelled up. Two days after sowing, beds should be watered and the watering should be continued every 3rd day until the plants come up. After the plants have appeared watering should be done every second day except when there is rain. When the plants are about 9″ high they should be transplanted, leaf stalks being cut off. The field to which they are removed should be got ready in the mean time, ridges being put up 3 ft. apart and the planting done on the ridges. If the stumps are planted the planting should always be done on ridges 3 ft. apart. If 7 or 8 stalks with roots are planted in each spot they will form a fine big clump. The stalks of the stumps planted should stick out 7″ or 8″ above ground. The clumps occupy wider and wider area as time goes on and as the plants get cut away. In extending the plantation some of the shoots can be taken up with roots and the roots planted, or after the shoots have been all cut away the stumps can be dug up leaving a quarter at each spot. Unless the stumps are

thinned out either in one or in the other way the shoots become hard and less palatable to horses and cattle. After every second cutting the land should be manured with 100 to 150 maunds of farmyard manure or tank earth or *jhil* earth *per bigha* per annum. Solid and liquid excrements of horses, men, sheep and goats have been found the best manure for guinea grass. After transplanting the seedlings or root-cuttings on to fields, watering should be done daily, unless there is rain, until the plants are well established. Afterwards in the dry season irrigation should be continued once a month. In the rainy season, of course, no irrigation is required. After the shoots are cut off, the land should be dug up at intervals between the plants, the weeds collected and destroyed and manure spread over and ploughed in and the ridges formed again. The shoots should be cut off before they run to seed that they may be gathered quite tender. If seed is wanted the shoots should be allowed to mature but clumps that are constantly cut produce weak seeds that do not germinate. Any seed stalks showing smut should not be touched but singed with fire. The guinea grass is not known to suffer from any other malady.

1,066. *Lucerne* (*Medicago sativa*).—The leguminous crop that is called lucerne or alfalfa is also perennial, *i e*, it will stand on the same field for 10 or 12 years running, if it is not allowed to seed and if it is properly attended to. It is a most nutritious fodder for horses; cattle should not be given too much of lucerne as it produces diarrhœa. The stomach of the horse, being comparatively of a small capacity, requires more nutritious food than that of cattle. Lucerne, therefore, is a most appropriate fodder for horses though not for cattle. This crop should be grown near large towns where good class horses are maintained. There is another special advantage in growing this crop. The roots of this crop penetrate several yards deep into the soil. It does not therefore suffer from drought when it has been once estab-

lished while it yields heavy cuttings 8 or 10 times in the year where facilities exist for irrigation. Fairly heavy soil, rich in lime and well drained, also dry climate, should be chosen for this crop. Lime and tank earth have been found very good manures for this crop.

1,067. *Cultivation.*—In April or May after the first shower of rain the land should be given one ploughing. At the end of the rainy season about 100 maunds of tank earth should be spread per bigha and the land ploughed and harrowed 4 or 5 times. After the cultivation is finished 3 or 4 maunds of lime per acre or 6 maunds of bone-dust should be sprinkled over the land. Trenches should then be made lengthwise so as to form ridges about 2 feet apart unless the land is hilly with a natural slope. The seed should be sown on the top of the ridges. Little holes may be made with a sickle and seed put in them and the earth battered down. Thus sown 4 seers of seed will be found sufficient per acre. If the plants do not come up within 10 days after sowing and if the soil appears to be too dry one or two waterings may be required before the plants come up. The plants being grown on the ridges or on hillsides, rain is not able to spoil them, and the trenches between the rows of plants can be utilised both for irrigating and for hoeing the land. After each cutting, the plough should be passed through the trenches and weeds cleared in this way. After every two or three cuttings manure should be applied in the trenches; in other words, if 3 cartloads of rotten farmyard manure are applied at one season and at another a maund of bone-meal or 2 maunds of castor-cake or rape-cake per bigha, 5 to 6 cuttings of plants may be had from the land during one year and an average crop of 50 maunds per acre can be obtained at each cutting, or 300 maunds of green food in all, during the year. With special facility for irrigation one can obtain 600 or 700 maunds of green stuff per acre. Europeans are quite familiar with the value of lucerne as a fodder for horses, and there should be no

difficulty in disposing of the crop in large towns, say, at Re.1 per maund. The fodder is specially valued for race horses. If plants are not cut, they run to seed after a year, *i.e.*, at the next cold season, and the plants wither away afterwards. Plants reserved for seed should not be cut but left untouched in a corner of a field. These should not be irrigated so often as the plants used for fodder. Plants required for seed should not be more than three years old. Any time within the first 3 years, any of the plants can be set apart for seeding. The seed is usually sold at Rs. 3 per seer, but as the crop is rarely grown in this country there is no market for any considerable quantity of the seed. A plant which is allowed to seed, whether it be in the first year, or afterwards, dies immediately afterwards.

1,068. Lucerne in flower has the following average composition:—

Water	74
Albuminoids	4·5
Crude fibre	9·5
Carbohydrates	9·4
Ash	2
Albuminoid ratio	1 : 2

1,069. *Khari sugar-cane* cut up small is an excellent fodder for cattle. The cactus of the Opuntia (*Phanimanasá*) class divested of thorns and given chopped up to cattle, and the leaves and tops of cassava, are also eaten by cattle.

1,070. Of annual and rank-growing leguminous fodder crops, *Barbati* or cow-pea (vigna catiang) and *Arharia Sim* (Cyamopsis Psoroiloides), called *kurti* in Oudh, occupy the first place. Ground-nuts should be grown as a fodder crop on clay soils as it grows in such soils, like a weed, always, after it is once sown, and it is thus practically a perennial leguminous crop.

1,071 *Albizza procera* or *rain-tree* being a very fast growing tree, and doing well in the plains of Bengal, should be largely grown for fuel. The fruits of this tree are very sweet and cattle are very fond of eating them. They are probably as good for fodder as the carob-beans of the Mediterranian regions. Prosopis spicigera and mulberry have been also mentioned as valuable fodder-yielding trees.

CHAPTER CIII.

SILOS.

SILOS are built either above ground or below ground or partly above or parly below, or on a slope. They are either old buildings modified or unmodified, or they are new ones specially constructed. A fourteen-inch brick or concrete wall carefully lined with cement is all that is required. The internal coating of cement should be as smooth as possible. If an old room be converted in a silo the door-way requires special arrangements for closing up before filling, and for opening before commencing using the silage. This is sometimes done by brick-work and sometimes by a double door of wood with saw-dust in the intervening space. The cost of silos should not exceed Rs. 10 per ton of capacity, a cubic ft. of silage weighing 45 or 50 lbs. Fifty cubic ft. should hold a ton. Stack-silos are also common. A stack 30 ft. long by 15 ft. wide (16 ft. at the base) and 14 ft. high would weigh about 100 tons. A pit at the side of a hill is the most convenient situation for a silo as it can be filled from the top and the fodder can be taken out from the bottom.

1,073. The greatest amount of mouldiness occurring just behind the door-way, or just beneath the covering boards, great

care is necessary in the construction of a silo. Small silos are better than large ones as the filling each time should be done within a day or two. The best size is 10 ft. × 10 ft. × 5 ft.

1,074. The best materials to pit are green maize stalks, *arahar* plants in flower; *juar*, sorghum saccharatum, buckwheat, barley straw and coarse grasses. The materials should be filled chopped up, if possible. For a 10 ft. square silo, 4 or 5 cwts. of material should be put in, and 1 lb. of salt sprinkled over the mass for every cwt. of material used, and the whole well trodden down specially at the sides and corners. This process is repeated until the whole of the pit is filled up. An extra quantity of salt should be sprinkled at the top and the whole of the pit covered with boards or *darma*-mats, earth being used for weighing the boards at 100 lbs. per square foot. A 10 ft. × 10 ft. × 10 ft. pit will hold about 5 tons of materials at the first filling. As the boards will gradually sink, crevices in the earth must be carefully filled, up. After a week or 10 days the silo should be opened again and filled in the manner already described, and closed again. The opening and filling may be repeated 4 or 6 times, *i.e.*, so long as there is considerable sinking. Properly filled, a pit 10 ft. × 10 ft. × 10 ft. will hold 10 tons of silage which is equivalent to 2 or 3 tons of dry hay. If necessary the silage can be used 6 weeks after the filling has been completed when fermentation will cease. But it will remain good for at least 2 years. In England 10 tons of green fodder produce 9½ tons of silage or 3 tons of dry hay. In India the loss of weight in silage-making comes to a great deal more. In 1892-93, at Allahabad 33,652 maunds of grass made 21, 781 maunds of silage, which means a loss of 35 per cent.

1,075. If a thermometer is available it should be seen that the top 3 or 4 ft. of the materials attain the heat of about 125°F before the second filling is done. The maximum temperature (160°F) is reached in about 6 weeks, after which normal temperature is attained in a few days. A silo should

not be opened until normal temperature is reached. About 5 per cent. of the silage is wasted at the sides and the top or at the door when there is a door, on account of mouldiness; and more, if air is not properly excluded. To make 60 lbs. of silage in India 90 or 100 lbs. of green fodder are required.

1,076. Heavy pressure and trampling and quick filling are no longer considered essential for getting best results in the making of silage. The mass may be allowed to settle of itself. When filling the mass should be made level and well pressed into the corners. It should be tight at the sides. Even a wooden cover over the top is not needed. A simple covering of cut straw answers. A wooden silo above ground is far better than any stone or brick building under or above ground. Stacking of silage is not recommended for this country. The waste from decay in stack-silage is great.

1,077. Silage is specially valuable for milch-cattle. It increases the flow of milk, makes the milk richer, and supplies food at a time of the year when fodder is scarce, the excess production of the rainy season being utilized for silage. That fibre is rendered more digestible by ensilage is the point which is of great importance in considering the value of silage as food as compared to hay.

1,078. Large sized cattle require nearly 30 seers of hay or silage per day and smaller sized cattle 20 seers or less; but the silage-fed cattle will milk better than hay-fed ones, the milk being richer in cream and the butter sweeter and richer in colour. The cost of feeding cattle with silage is less than half of feeding them with hay or with straw-chaff and bran or oil-cake. An acre of green fodder, say, Guinea grass, may weigh 10 tons. This will make 3 tons of dry hay, but 7 tons of silage. The 3 tons of dry hay will keep 168 head of cattle for a day or 1 cow for 168 days at 40 lbs. a day, while the 7 tons of silage will keep 392 head of cattle for a day, or 1 cow for 392 days.

1,079. Pit-silage is more sour than stack-silage, but cattle will eat either. The acidity is due to acetic, lactic and other acids which are generated when the temperature rises to 80 or 100°F. The albuminoids get partly converted into acids, which is a loss, and the albuminoid ratio of silage being less, some nitrogenous food, such as bran or oil-cake should be used with silage. Silage is also a mild laxative food which ordinarily does no harm, but when diarrhœa sets in, bean-meal should be given along with silage or hay and straw partly substituted for silage. Generally speaking, 10 to 15 seers of silage along with other food should be given per diem to a cow.

1,080. The relative merits of hay and silage are thus summed up by Dr. Leather :—

" The grass used weighed 34,442 lbs. ; the hay 11,152 lbs. ; the loss 20,290 lbs. or 67·62 per cent. Of this 64·57 per cent. was water. The remainder was almost entirely due to the loss of a part of the digestible fibre, woody fibre and carbohydrates present in the grass. The amount of these together in the fresh grass was 8,668 lbs. and in the hay 7,670 lbs., the loss was therefore 998 lbs. or 11·5 per cent. Of the albuminoids present in the grass there was no loss, and a considerable proportion of the insoluble albuminoids became soluble ; of the total N originally present there was slight loss—the grass contained 160 lbs. whilst the hay contained 150 lbs. During the process of hay-making, therefore, the loss of food material is but very slight, and what is lost consists principally of carbonaceous principles."

1,081. With regard to some English silage Dr. Leather says : The digestible fibre, the woody fibre and the carbohydrates in the grass weighed together 8,213 lbs. ; those in the silage 6,989 lbs. and the loss 1,224 lbs. Some acetic and lactic acids were formed, amounting together to 215 lbs. Allowing these to have the same value as the carbohydrates, the net loss of carbonaceous food was 1,009 lbs. or 12·3 per

100 parts of carbonaceous principle. Of the total N in the grass employed there was no loss; 151 lbs. N was found in the grass and 155 lbs. N in the silage. There was however a loss of albuminoids, a portion of these being converted into non-albuminoid substance. The albuminoids in the grass amounted to 780 lbs., in the silage to only 449 lbs.

"Of the quality of the silage, it will be sufficient to say, that the silage was employed in a comparative feeding experiment on bullocks: one lot of beasts being fed on cotton seed-cake, maize and silage, the other on cotton seed-cake, maize and hay, the result of which was to show the feeding value of silage to be slightly superior to hay.

"It is economical to store the early grass as silage in those districts which are too wet to admit of hay-making, and ensilage is therefore a process by which fodder may be stored for many months and it may be regarded as a means of providing for scarcity of fodder in dry years."

1,082. Pasturing or giving green grass to cattle and horses is the best. Next to that should be preferred giving of silage to cattle, but horses requiring more concentrated food richer in albuminoids, hay is better for horses than silage. Even milch-cattle thrive better on silage than on hay, although they require their food to be of a higher albuminoid ratio than horses, but then they must get some bran or oil-cake along with silage, as bulkier food is more suited to ruminants than to horses.

1,083. *The Allahabad Grass Farm.*—As a Government Farm which is worked with profit, it will be interesting to give a few details of this Farm taken from the report of 1890-91, *i.e.*, the year immediately preceding the establishment of the dairy farm and cattle and pig breeding in connection with it. The year was rather droughty and the average yield of grass was only 126 maunds per acre as compared to 155 maunds per acre obtained in 1889-90. The extent of the Farm was 2,590 acres. The rent paid

was high *i.e.*, Rs. 16,999-6-5, *i.e.*, over Rs. 6 per acre. The total yield of green grass came to 325,821 maunds. 250 acres were cropped with sorghum, oats, barley, wheat and gram, which yielded 15,984 maunds of grain.

1,084. Of the green grass obtained, 153,102 maunds were issued in the green state, 120,739 maunds were made into hay, 51,749 maunds of hay being obtained, while 51,981 maunds were siloed, 34,723 maunds of silage being obtained from 35 silos.

1,085. The loss by dryage and mouldiness in the case of silage varied from 16·12 per cent. to 52·62 per cent., the average coming to 28 per cent.

1,086. Rs.8,886-10-6 was the amount spent during the year on manuring, while the total expenditure came to Rs. 79,797-10-8.

1,087. The produce was not sold but supplied to the Commissariat Department, and an estimate only of the produce can be given.

(1)	*Green grass*	...	1,53,102 mds.	@	3 as. a mnd.	= Rs.	28,705
(2)	*Hay*	...	51,749 ,,	,,	8 ,, ,,	= ,,	23,874
(3)	*Silage*	...	34,723 ,,	,,	8 ,, ,,	= ,,	17,361
(4)	*Grain*	...	15,984 ,,	,,	Re. 1 ,,	= ,,	15,984

Total gross outturn	... Rs.	87,924
Deduct Total Expenditure	... ,,	79,797
Net saving to Govt.	... Rs.	8,127.

CHAPTER CIV.

ALBUMINOID RATIO.

DIFFERENT animals have different power of digestion, and even the same animal digests different proportions of food constituents under different circumstances.

1,089. The digestible carbohydrates are all assumed to have the same heat-producing power, but as a matter of fact they differ in this respect in their action in different animals, ruminants making better use of them than other animals. Different animals require foods of different 'albuminoid ratios' to sustain them in proper health. By *albuminoid ratio* is meant the ratio of the digestible proteids to the digestible carbohydrates *plus* 2·3 times the digestible fat or oil. But as the proportions of albuminoids and carbonaceous food-constituents digested are different under different circumstances, the term albuminoid ratio is more commonly applied simply to the ratio between the albuminoid and the carbonaceous food-constituents, the latter including fat which is multiplied by 2·3 and then added to the carbohydrate food-constituents. The difference between the *true albuminoid ratio* and the albuminoid ratio as ordinarily understood is not very great, and for ordinary purposes, *i. e.*, in ascertaining the value of a food, the digestibility of its different constituents may be left out of account.

1,090. The different constituents of all crops are not equally digestible and all crops are not equally digestible in all conditions and stages of growth. Fodder crops deteriorate towards maturity and they are wanting in nourishment when too young. In the case of *Juar*, the highest nutritive and manurial value is immediately before flowering, but potatoes and mangolds improve with

maturity, starch and sugar being formed more freely at the latest stage of their growth. High manuring increases not only the bulk of a crop, but also the relative proportions of water, ash and nitrogen, but there is a smaller proportion of albuminoid matter and of carbohydrates in highly manured crops. The difference in the sugar-producing capacity of two lots of sugar-cane, one highly manured and the other not manured at all and very indifferently irrigated, was lately tested in the Cossipore Sugar Factory. The figures obtained were—from 104 maunds of poorly grown sugar-cane which were crushed after topping, were obtained 11 maunds and 21 seers of clean *i. e.*, clarified *gur*; 28 seers of filter-mud and 4 seers of scum. From 23 maunds and 37 seers of well grown canes were obtained 17 maunds 7 seers of juice, which yielded 4 maunds and 2 seers of clean *gur*, 13 seers of filter-mud, and 2 seers of scum. Thus the proportion of *gur* obtained in the one case was $\frac{162}{957}$, or roughly speaking $\frac{1}{6}$, and in the other (*i.e.*, in this case of the poorly grown canes) $\frac{461}{4160}$, or roughly speaking $\frac{1}{9}$.

1,091. In hay, straw, green-fodder and root-crops, the nitrogen present is no guide to the amount of albuminoids. The fat in these substances also contains a good proportion of indigestible wax, and some portions of the carbohydrates also have no feeding value. Weight for weight these constituents in grains are better digested than in fodders.

1,092. No experiments have been conducted on Indian animals to test the digestibility of the constituents of the various food-stuffs, and we must at present rely on European and American experience in the matter.

1,093 Digestibility has been found affected by the following circumstances; (1) Kind of animal, whether ruminant or not; (2) quality of food; (3) mixture adopted; (4) age of the plant used for fodder; (5) the state in which the food is given,

in the rough, or properly washed, or cooked, or dried as hay and (6) health.

1,094. Digestibility is not affected by the following circumstances: (1) age of the animal; (2) quantity given (*i. e.*, by starving an animal a higher proportion of the small quantity given is not digested); (3) labour (*i. e.*, bullocks at rest and at work digest the same proportions of the different constituents).

1,095. The addition of the following substances to food helps digestion :—

(1) Nitrogenous food, such as bran, oil-cake, wheat, bean-meal &c.

(2) Oil, at the rate of ½ lb. per day per 1,000 lbs. of live-weight.

(3) Starch or sugar, *e. g.*, potatoes, mangolds, provided the albuminoid ratio of the whole food does not fall below 1 : 8. The addition of starch or sugar ordinarily reduces the digestibility of food, but when the albuminoid ratio is increased by the addition of oil-cake, bean-meal &c., then the digestibility of the food is increased by the addition of sugar or starch.

(4) Salt.

(5) Agreeable flavour is also helpful to digestion, hence the advisability of mixing fenugrek.

(6) The proper proportion of water is of great value in helping digestion. In the case of cattle the proportion of water to dry food should be as 4 : 1, and in the case of sheep as 2 : 1; but in this climate a higher proportion of water is probably necessary.

1,096. Grains, potatoes, and root-crops generally are nearly completely digested. The higher the proportion of nitrogenous matter contained in hay or straw the greater is its digestibility. Of 100 parts of fat, proteids, carbohydrates and fibres, in various food-stuffs, the proportions digested are given below, though the figures must be understood in

connection with the reservation that different animals have different power of digesting different constituents of food in different mixtures, and the figures therefore give only a general idea.

	Fat.	Proteids.	Carbo-hydrates.	Fibre.
Cereal grains ...	85%	75%	85 %	Very variable.
Pulse grains ...	80 „	85 „	90 „	60 „
Cereal straw ...	—	20 „	45 „	55 „
Pulse straw (not too ripe) ...	—	45 „	60 „	40 „
Hay	—	50 „	60 „	50 „
Oil-cake	90 „	80 „	50 to 80 „	Very variable.
Potatoes ...	90 „	72 „	93 „	

1,097. Let us now find out the albuminoid ratio or nutritive relation of Bengal gram (Cicer Arietinum). Its average composition is

Moisture ...	10·6%	(the nutritive value of which is to be neglected).
Oil	4·4%	(which is equivalent to 4·4 × 2·3 of starch).
Albuminoids ...	17·1%	
Other Nitrogenous matter.	1·5%	(which may be reckoned as equal to starch).
Carbohydrates ...	57%	
Woody fibre ...	6·3%	
Mineral matter ...	2·7%	(the nutrient value of which is to be neglected).

1,098. From the table of digestibility given above we conclude that—

80 per cent. of the fat which has been reduced to carbohydrates as 4·4 × 2·3 is digestible, also, that 90 per cent. of the carbohydrates the proportion of which is 57 per cent. is digestible, also, that 60 per cent. of the fibre (6·3 per cent). and 90 per cent. of the other nitrogenous matter

(1·5 per cent.) which is equal in value to starch, are digestible. We also conclude, that 85 per cent. of the albuminoids, the proportion of which is 17·1, is digestible. Now the proportion between the digestible albuminoids and the digestible portions of the food reckoned as starch is the true albuminoid ratio of gram. In working the proportion out we have the following result:—

$$\frac{17{\cdot}1 \times 85}{(57 \times 90) + (1{\cdot}5 \times 90) + (6{\cdot}3 \times 60) + (4{\cdot}4 \times 2{\cdot}3 \times 80)}$$

$$= \frac{14{\cdot}535}{513 + 1{\cdot}35 + 3{\cdot}78 + 8{\cdot}096} = \frac{14{\cdot}535}{64{\cdot}526} = 1 : 4{\cdot}4$$

1,099. The food of a working bullock should have an albuminoid ratio of 1 : 13; of horse 1 : 11 ; and of a cow in milk 1 : 7½. Cow's milk which is highly nutritious food has the albuminoid ratio of 1 : 5 and of goat's milk 1 : 4½. Food of young and growing animals should, therefore, have the albuminoid ratio of 1 : 5.

1,100. In mixing different foods for farm animals the albuminoid ratio suitable for each should be borne in mind as much as possible that economy in feeding may be attended with the best of results. If the albuminoid ratio is too high it is waste of good food, if it is too low the food is too poor as a flesh-former.

1,101. The following table of albuminoid ratios gives an idea of the value of different foods for animals.

	Albuminoid ratio. (Nominal) (True)	Digestible proteids.
Indian wheat grain	... 1 : 9·4 (1 : 12)	7%
„ wheat bran	... 1 : 7·3 (1 : 4·2)	7 „
„ wheat straw	... 1 : 25 (1 : 20·4)	·6 „
„ barley grain	... 1 : 11 (1 : 7·6)	6 „
„ oat grain	... 1 : 13 (1 : 5·5)	5 „
Rice grain ...	... 1 : 20	3·5 „
Rice husk ...	... 1 : 18	2·4 „
Rice straw ...	... 1 : 43	·4 „

	(Nominal) (True)	Digestible proteids.
Juar grain ...	... 1 : 10 ,,	6 6 %
Juar straw ...	... 1 : 54 ,,	·5 ,,
Hay ...	... 1 : 23 ,,	2 ,,
Linseed cake	... 1 : 2·3 ,,	26 ,,
Earth-nut cake	... 1 : ·8 ,,	36 ,,
Til cake ...	... 1 : 1·7 ,,	72 ,,
Decorticated cotton-cake	1 : 1·5 ,,	38 ,,
Indian cotton seed-cake	... 1 : 4 ,,	13 ,,
Peas ...	... 1 : 2·7 (1 : 2·9)	16 ,,
Bengal gram	... 1 : 4·4	14 ,,
Mangolds ...	... 1 : 31 (1 : 8)	1·2 ,,
Potatoes ...	... 1 : 18 (1 : 10·6)	2·1 ,,
Maize ...	... 1 : 9	·8 ,,

1,102. Let us now see what the albuminoid ratio of a mixed ration consisting of 17 lbs. of hay and 6 lbs. of gram, is. We can find from the table of composition of hay, as we found in the case of gram, that it contains in every 100 lbs. 2 lbs. of digestible albuminoids and 46 lbs. of digestible carbonaceous food. ∴ 17 lbs. of hay contains ·34 lbs. of digestible proteids and 7·82 lbs. of digestible carbonaceous food or food calculated as starch. We also know that 100 lbs. of gram contains 14 lbs. of digestible proteids and 61·6 lbs. (14 × 4·4) of carbonaceous food calculated as starch. 6 lbs. of gram would thus contain ·84 lbs. of digestible proteids and 3·69 lbs. of starch. In the mixed ration therefore there is 1·18 lbs. of digestible proteids and 11·51 lbs. of starch. The albuminoid ratio of the mixed food is thus 1·18 : 11·51 or nearly 1 : 10. The food is thus a little too rich for horses and bullocks, though not rich enough for a cow in milk nor for young growing animals.

1,103. In mixing foods the ash constituents cannot altogether be left out of account. Maize and rice, for instance, being extremely poor in lime are unsuitable for young and

growing animals. Straw and hay are particularly poor in phosphoric acid, and as bran and oil-cake are particularly rich in P_2O_5 one of these substances should be given to young and growing animals and animals in milk along with hay or straw.

1,104. So the scientific farmer should look not only to the albuminoid ratio, but also to the mineral requisites of food he chooses for his various livestock, and he should consider such other circumstances as cleanliness, flavour &c., which are valuable aids to digestion.

1,105. For calculating the *total nutriment* contained in a food-stuff, the proportions of fibre, ash, and moisture contained in it, are ignored, though, as we have just said, they are not without value. The values of albuminoids and of carbohydrates are assumed to be equal. The fat contained in the food-stuff is calculated as being 2·3 times as valuable as either the carbohydrates or the albuminoids. To ascertain, for instance, the nutrient value of paddy-straw, which contains 40·65 per cent. of carbohydrates, 1·78 per cent. of albuminoids and 2·19 per cent. of fat, one has simply to add together, 40·65, 1·78 and (2·19 × 2·3), the result coming to 47·467.

1,106. Although chemical analysis gives no exact idea as to the digestible and other practical value of fodders, yet the following table will be found of some use in determining the merits of fodders :—

Fodder.	Moisture.	Ash.	Fibre.	Fat.	Carbo-hydrates.	Albu-minoids. *	Albu-minoid ratio.	Total nutriment.
	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.		
Paddy straw ...	8·12	16·87	30·02	2·19	40·65	1·78	1 : 43	47·4
Wheat straw ...	8·78	4·16	44·99	1·29	37·33	3·45	1 : 25	43·7
Oat straw ...	8·74	4·81	41·52	2·22	38·89	3·82	1 : 23·5	47·8
Sorghum straw ...	8·06	7·08	30·93	3·14	48·91	1·61	1 : 54	56·4
Marua straw ...	9·88	12·10	28·22	2·37	44·88	2·19	1 : 36	52·7
Barley straw ...	15·20	4·26	66·54	1·36	8·21	4·43	1 : 17	15·7
Maize straw ...	9·57	5·23	29·97	1·10	49·17	5·02	1 : 16	56·7
Green Lucerne ...	74·00	2·00	9·50	1·00	9·40	4·50	1 : 2·5	16·2
Dehydrated Lucerne	*Nil*	9·40	26·20	3·40	43·90	17·10	1 : 2·5	68·8
Average cereal ...	11·62	2·00	3·00	3·00	71·26	9·12	1 : 12	87·3
Average Pulse ...	10·00	3·00	7·14	3·50	51·30	25·06	1 : 3·5	84·41

* $N = \frac{\text{Albuminoid}}{6{\cdot}25}$

CHAPTER CV.

MANURIAL VALUE OF FOOD-STUFFS.

RELATION of food to growth and excrements.—Generally speaking, an animal requires, as sustenance diet, 4 lbs. of food to every 100 lbs. of live weight and the relation between dry food and water should be about 1 : 4. Ruminants require larger quantities of coarse food and animals with small stomachs, such as the horse, require smaller quantities. 4 to 8 per cent. of the food consumed is assimilated and the rest is voided. One part of the Nitrogenous food is voided in fæces and two parts in urine. A growing animal increases about 1 lb. in weight for every 8 lbs. of food consumed above the sustenance diet. The proportion of increase of weight in pigs is larger *i.e*, they increase 1 lb. in weight by consuming only 4 to 5 lbs. of food above the mere sustenance diet. Sustenance diet is what will keep an animal from starving or decreasing in weight. The increase in weight is due chiefly to the accumulation of water and fat and mineral matters. The proportion of development between albuminoids, water and fat while an animal is fattening is as 1 : 3 : 7 and the proportion of ash in lean meat to fat meat is as 1 : 3.

1,108. Cattle-foods vary very much in their manure-value. The manurial value of food-stuffs depends entirely on the proportions of nitrogen, phosphoric acid and potash they contain. From these must be deducted the proportions of these constituents utilised by the animals in the building up of their bodies. Except in the case of growing animals

and of milch-cattle, the proportions of manurial substances lost to the land by the utilisation of food-substances as food first, are insignificant. In the case of nitrogen alone, Lawes and Gilbert deduced 10 to 15 per cent. of loss, as there is more wastage of nitrogen than of phosphoric acid and potash; though it was also recognised that in the case of highly nitrogenous food-substances, like oil-cake, bean-meal &c., the manurial value of the dung is specially great. As cattle-food, linseed-cake is the best of all foods, that is, more fattening than other food-stuffs, but the manurial value of decorticated cotton-cake is much greater, as the proportions of N, P_2O_5 and K_2O contained in decorticated cotton-cake are much greater than in linseed-cake. It is, therefore, from the chemical composition of food-stuffs in these three constituents, that we are to infer their manurial value, making a slight deduction in the case of P_2O_5 and K_2O and 10 to 15 per cent. deduction in the case N. If the farmer considers the manurial value of such food-stuffs as oil-cakes or leguminous seeds, he would not grudge giving a liberal allowance of these to his cattle, as by so doing he would not only have his animals, but his land also, "in condition."

1,109. All the organic manures act slowly on the land, *i.e.* even after a crop is taken, it is assumed that half the dung applied to the land still remains unexhausted, and after two years, a third is still unexhausted. If annually cattle are hurdled on a piece of land and given oil-cake, or gram, to eat, while so hurdled, the land will get richer and richer, and the accumulated fertility of 8 or 10 years will bring it to a high condition, after which careful cropping and manuring may help to keep the land always in this condition.

1,110. The following figures will give an idea of the

manurial value of some of the principal purchased food-stuffs:—

	Bran.	Linseed-cake.	Decorticated cotton-cake.	Rape-cake.	Peas.
Nitrogen in 1 ton of food.	56·00 lbs.	106·40lbs.	147·84lbs.	109·76lbs.	80 64lbs.
Nitrogen in the manure from the food.	52·84 ,,	101·66 ,,	143·46 ,,	106·92 ,,	76·58 ,,
Phosphoric acid in 1 ton of food.	80 64 ,,	44·80 ,,	69·44 ,,	56 00 ,,	19·04 ,,
Phosphoric acid in the manure from the food.	78·50 ,,	41·59 ,,	66·48 ,,	54·07 ,,	16·29 ,,
Potash in 1 ton of food.	32·48 ,,	31·36 ,,	44·80 ,,	33·60 ,,	21·50 ,,
Potash in the manure from the food.	32·21 ,,	30·95 ,,	44·42 ,,	33·35 ,,	21·15 ,,

CHAPTER CVI.

MILK.

MILK is an emulsion of fats and proteids in a solution consisting of lactose (milk-sugar), some soluble proteids

and a little mineral matter. The compositions of the principal dairy produce are given below:—

	Buffalo milk.	Cow's milk.	Goat's milk.	English cow's milk.	Butter.	Separated milk.	Buffalo milk cheese	English cheese from cow-milk.
Water ...	81 to 86	85 to 88	86	87	7 to 20	91	15	30 to 40
Fat ...	4·6 to 9·2	3·9 to 6·2	4·7to5·5	3·8	70 to 89	1 to 2	50	25 to 30
Casein and other albuminoids	3·5 to 4	2·5 to 3·5	3·4	4	·2 to 2	3	30	25 to 30
Sugar ...	5	5	3·9	4·6		5	5	
Mineral matter	·8	·7	·6 to ·9	·7	·1	·7 to 9		
Nitrogen ...	·6	·48	·54	·64	Trace.	...	4·75	...
Phosphoric acid	...	...	...	·19	...	...	...	...
Potash ...	...	...	...	·12	...	...	...	...
Lime ...	...	...	...	·18	...	...	...	...
Sp. Gr. at 25 °C	1·030	1·030	...	1·031	...	1·036	...	...
Dry matter ...	...	...	...	10 to 16 %	...	...	...	...

1,112. The composition of milk differs very much according to the food and the yield. The larger the quantity given by a particular cow the poorer it is in fat. Watery food also results in poor milk. The last strippings are the richest in fat. The average composition of milk out of a herd of 20 cattle is fairly uniform.

1,113. Milk is not a homogeneous substance. The butter fat which has the specific gravity of ·91 being suspended in a solution of sugar (lactose) and proteids the specific gravity of which is 1·03, is not evenly distributed through the whole quantity of milk. One sample of milk from the same cow therefore differs from another sample, and a representative sample from a particular cow is difficult to get, though the mixed milk of a large dairy is fairly even in composition.

1,114. Buffalo butter, having a higher melting point than cow's butter can be easily distinguished from the latter. *Ghee* contains less water and casein than butter and it has a slightly higher melting point and specific gravity. Butter fat consists chiefly of glycerides of palmitic and oleic acids. The glycerides of stearic, myristic, lauric, capric, capryllic, caproic and butyric acids, are also present in small quantities. The glycerides of oleic, capric, capryllic, caproic and butyric acids are fluid in ordinary temperature, the remaining glycerides being solid. In summer the proportion of fluid fats is greater than in winter. Food also has a great effect on the fats of butter. Rape-cake, cotton-cake, oats, and wheat-bran produce harder butter, while linseed-cake, peas, and barley produce soft butter.

1,115. When butter or ghee becomes rancid, the glycerine compounds are decomposed and the acids set free. The butyric, caproic, capryllic and capric acids having a strong smell, produce the characteristic smell of rancid butter and ghee. Since these acids are also slightly soluble in water and more so in milk, the disagreeable smell of rancid butter can be got rid of by several washings with water, or better

with milk. Lard and vegetable oils are deficient in these volatile acids, and this fact helps the detection of adulteration of butter and ghee.

1,116. The albuminoids of milk consist of casein and albumin. The former is separated out by rennet but not the latter, while the latter is separated out by boiling. In *shar* we have butter and albumin, while in cheese we have butter and casein. In colostrum albumin greatly preponderates, so that it coagulates on boiling. In ordinary cow's milk, $\frac{1}{9}$ of the albuminoids is albumin and $\frac{8}{9}$ is casein.

1,117. The *souring of milk* is caused by Bacillus lactis. If this bacillus can be excluded by sterilization and preservation in air-tight vessels, the milk can be kept sweet for an indefinite period. There is a future for the sterilized milk trade in India. The bacterium acts on the lactose of the milk converting it into lactic acid. The acid acts on the casein and precipitates it, which causes the curdling of the milk. Rennet which is also a ferment acts on the casein at a moderately high temperature and precipitates the coagulated casein. But the production of lactic acid is not necessarily effected by the addition of rennet nor is such production the cause of coagulation in cheese making. The addition of rennet however turns the milk sour, other acids being generated. Any acid except carbonic acid, will coagulate milk, *i.e.* cause the casein and the fat entangled in it to precipitate.

1,118. There are more than one rapid process in use for *determination of the richness of milk.* The old lactometer test is useless, as skimming the butter increases the specific gravity of milk and an addition of water lowers this specific gravity. A dishonest dealer with the help of a lactometer can easily remove the fat by the rapid centrifugal process and then by addition of water bring up the specific gravity to 1·031 or 1·030.

1,119. The *lactocrite methods* of testing milk are not very satisfactory either. The idea in all these methods (*e.g.*

Babcock's method) is to dissolve the casein by a strong acid say H_2SO_4 of sp. gr. 1·82. When their action goes on, there is a great rise in temperature, the fat liquifies and when submitted to the centrifugal force it all comes to the surface and is measured in the graduated neck of the test bottle. The fault in these systems lies in the fact that owing to the great rise in temperature due to a strong acid being mixed with the milk, some of the fat, with milk-sugar, gets charred to a black substance which consequently interferes with the obtaining of accurate results.

1,120. *Gerber's method* overcomes this difficulty by the addition of amyl alcohol, and it is at present considered the best and quickest volumetric test for milk-fat.

1,121. The first stage in the process is sampling of the milk by tilting it from pail to pail until the cream is well distributed throughout the whole. The sampling should be done when the milk is still warm from the cow.

1,122. A number of safety pipettes are then got ready, *i.e.*, 10 c. c. pipettes for acid, 11 c. c. pipettes for milk, and 1 c. c. pipettes for amyl alcohol; also test bottles fitted with rubber corks and chemicals for test.

1,123. The sulphuric acid used should be of the sp. gr. 1·82; a little more or less does not matter.

1,124. First of all, 10 c. c. of the sulphuric acid are taken in a pipette. Then the test bottle is inverted in a stand and the acid is run into it. The drop or two of acid remaining in the tip of the pipette is not to be blown in. Next is put in 1 c. c. of amyl alcohol (on the top of the acid), which will slightly discolours when coming in contact with the acid. The greatest possible care must be observed in measuring the amyl alcohol, as an extra drop or two affects the result most remarkably. It does not matter so very much if a slight error is made in the measuring of the milk or the acid.

1,125. Next, the milk is to be let in from the pipette drop by drop. Having put in the measured proportions of all

the ingredients, the test bottles are corked and well shaken before they are put on the rotary machine. The test bottles are now submitted to centrifugal force in the machine for 2 or 3 minutes after which they may be taken out.

1,126. The fat will be noticed to have collected on the top of the liquid, that is, if the operations have been properly performed, and it is generally of a palish yellow colour. To read off the percentage, the fat must be brought on the graduated scale on the neck of the bottle. This is done by pushing in the India rubber cork. The bottom of the layer of fat is to be got even with one of the long graduations, or where one sees one of the numbers, and then it is a simple matter to read off the percentage. Each space between the numbers represents one per cent., which is sub-divided into 10 small divisions each equal to ·1 per cent. So that if we have three large divisions and five small ones this would represent 3·5 per cent. of fat, which is the composition of good milk. In reading, it is necessary that the bottom of the fat should be exactly on one of the large marks, and in reading off the decimal percentage read up to the bottom of the meniscus, which is always present at the top of the fat.

1,127. The ash or mineral matter in the milk generally settles at the bottom of the test bottle near the cork in the form of a greyish white powder.

1,128. The test bottle is to be cleaned out with hot water immediately after use and if any fat is left in the neck it should be removed with a fine brush or else it will affect the accuracy of the next test.

1,129. The test of butter in milk is no criterion by which one could judge *fraudulent adulteration.* One sample of milk may be so rich that it contains $7\frac{1}{2}$ per cent. of butter and another may contain only $1\frac{1}{2}$ per cent. It is very hard to say whether a sample of milk has been watered, or the cow producing the milk has been fed injudiciously. Ordinary good milk should give 9 to 10 per cent. of cream and about $3\frac{1}{2}$ per

cent. of butter. One good Indian cow giving 5 or 6 seers of milk per day should produce annually 100 lbs. of butter or 250 lbs. of cheese. An average English dairy cow produces twice as much. One pound of cheese is obtained from about ten pounds of whole-milk or fifteen pounds of skim-milk. The produce of cheese is a more reliable test of the purity of milk than the produce of butter.

1,130. As cow's and buffalo's milk contain almost the uniform proportion of 5 per cent. of lactose and as the lactose is converted by souring into lactic acid, the *estimation* of the *percentage of lactic acid* in a sample of sour milk is a still fairer and a more feasible test of the purity of milk. The exact proportion of lactic acid contained in a sample is found out by the following titration test :—

Take one 50 c. c. burette with glass tap ; one burette stand ; one 50 c. c. test measure ; one piece of glass rod ; a glass tumbler or white tea cup ; 1oz. alcoholic solution of phenol phthalein (1 in 500) ; and ½ gallon decinormal solution of caustic soda (*i. e.* 4 grammes of pure caustic soda to 1 litre of distilled water). Then take a sample of the sour milk, after it has stood for at least half an hour at or near the temperature of 60°F. Shake the whole to get a fair sample. Measure 50 c. c. and transfer to a tumbler or tea cup. Wash out the measure to get all the milk and add this water to the sample. Into this stir with the glass rod 6 drops of the indicator or phenol phthalein solution. Fill the burette up to zero with the decinormal solution of alkali. Turn the tap and allow it to flow on to the milk containing the indicator. Keep up a brisk agitation with the glass rod. A bright pink colour develops as soon as the alkaline solution reaches the milk, but as rapidly disappears as the stirring is maintained. A point however is reached when the pink colour becomes permanent, and is observed throughout the milk. Turn off the fluid quickly by means of the tap, and then read off the register of the

burette the exact amount of alkaline solution in cubic centimetres that is required to produce this effect. This permanent colour shows the exact point at which the alkali neutralises the lactic acid, and proves an essential factor in estimating the percentage of acidity. Each cubic centimetre of alkaline solution will neutralise ·009 per cent. of lactic acid. If, for instance, the milk sampled becomes neutral with 12 c. c. of the solution, then $\frac{12 \times \cdot 009}{50} \times 100 = \cdot 216$ per cent. of lactic acid must have been present in the sour-milk. The equivalent proportion of lactose present in the fresh milk can then be deduced.

CHAPTER CVII.

CREAM AND BUTTER.

CREAM consists mainly of the fat-globules of milk which are separated when the milk is in the fresh state. In the hot weather, even with a centrifugal cream separator, it is not easy separating cream from milk, except with the help of ice. In the cold weather, early in the morning or at night, this separation can be effected very easily. Cream is also separated from fresh milk by setting the milk, in the cold weather, in shallow pans. The milk after being strained through clean cloth is placed in the evening in shallow pans about 4″ deep in a clean ventilated house; and in the morning with a scoop containing fine holes the cream resting on the top is cut out. If a second skimming is done, the creams of the two skimmings should be mixed up with a wooden stirrer. If a Cream-separating machine is used the separation can be effected in the morning or at night in a few minutes. Whether the separation is effected by the use of shallow pans or by a centrifugal cream-separator,

the fat-globules separated out will be found to be still mixed up with casein and sugar of the milk ; the cream obtained is thus not butter. It is not even butter diluted with a little milk, as fermentation plays a part in the formation of what we generally call butter. Although the fat-globules from fresh cream can be churned out into a very tasty butter, it is not proper butter that will keep for any length of time.

1,132. There are various kinds of Centrifugal machine (Fig. 62) in use ; the principle of all being the same : the



62 Fig.—The Cream-Separator.

heavier liquid is thrown out through a hole into a vessel and the column of fat globules collecting in the middle, gradually works its way through a separate hole and a separate spout into a separate vessel. For this country, the steam-power separators are not well adapted, nor the very expensive hand separators either, which cost Rs. 300 to Rs. 500. The 'Lilliput' separator which is only 18" high seems best suited for the needs of our dairy-men (*gowálás*) some of whom may be induced to invest Rs. 100 on this machine if the benefit of obtaining a larger quantity of cleaner butter from fresh milk throughout the cold months, can be pointed out to them. In one hour a maund of milk may be treated with this

machine, the average yield obtained being about 4 seers of cream per maund of milk.

1,133. The English *method of making butter* out of cream is not suitable under ordinary conditions in the climate of Bengal, as the proper temperature for churning is 55°F going gradually up to 62° or 64°F. Though sweet cream got by means of a centrifugal separator makes the best butter, we must depend in this country on making of butter from curd or sour-milk, or from *shar* which is practically the Devonshire method of making butter. The *making of cheese* is also not suited to the climate of Lower Bengal. The temperature at which the milk should be curdled by the addition of rennet is of great importance. 74° to 84°F is the suitable temperature, the lower temperature, (74° to 80°F) for thin cheeses and the higher (80° to 84°F) for thick. For the subsequent ripening of cheese a fairly unifrom temperature of 70°F is also needed. It is difficult to secure these conditions in the plains.

1,134. The *appliances necessary* for a small dairy of 25 cows, yielding an average quantity of 50 seers of milk daily are a Lilliput separator, a ten gallon churn (Fig. 63), two



FIG 63.—THE BUTTER CHURN.

pails for milking, a hair-sieve for passing the milk into the receptacle of the separator, two-glazed earthen-ware cream-

crocks each holding 10 seers of cream, two wooden stirrers, a butter tub, two wooden patters, a butter-worker (Fig. 64),



FIG. 64.—THE BUTTER-WORKER.

butter prints, a marble-slab and butter scales. All the utensils should be washed with boiling water and kept scrupulously clean. The cream should be kept in the cream-crock, and the fresh skim-milk may be either converted into cheese, or given to animals, or sold as inferior milk. After each separation of cream an addition may be made to the same cream-crock, but at each addition the stirrer should be used for mixing up the different lots of cream, and the churning may take place on the 2nd or 3rd day. The cream-crocker should be placed in a cool place. The churning should be done early in the morning at a temperature of about 60°F. The churn is only half filled with cream. During the first few minutes the ventilator of the churn should be opened out. The churning should continue for about 3 hours, at a uniform rate of about 40 strokes per minute. When the butter has come a difference of sound is noticed. Then the *butter-milk* is withdrawn from the churn, the flowing out of gra-

nules of butter being avoided by the use of the hair-sieve. Any granules accumulating in the sieve are to be returned to the churn. Then the churn is to be half filled with cold water, and after a few turns of the churn the water is to be withdrawn in the same way as the butter-milk. The washing is to be repeated until the water comes out clean. Then the butter is to be taken out, but it should not be touched with the hand. Either the hair-sieve or the two wooden patters are to be used. When the butter has been removed from the churn it is dealt with by the worker, which is a corrugated cylinder which kneads and rolls the butter against a table. The kneading may be also done with hands well washed with salt-water, in a tub. Salt is added now to remove the water more effectually and also to enhance the keeping quality of the butter. About 3 ounces of salt should be used for every 2 seers of butter. The mass is then made up into half pound rolls or prints.

1,135. We will have occasion to refer to butter-making again in the next Part of the book, in the chapter devoted to Dairy Bacteriology.

CHAPTER CVIII.

CHEESE-MAKING.

CREAM-cheese.—Take one gallon of fresh cream in a glazed earthen-ware vessel, heat or cool it to a temperature of 68° to 70°F. If the cream has been obtained by a separator allow it to stand for 4 to 6 hours to ripen. Add 15 to 20 drops of Hansen's rennet diluted with a little water. Stir this in for 10 minutes, afterwards covering the vessel,

and allow it to stand for 24 hours undisturbed in a temperature of 60°F. It will be now found to have coagulated, and then it should be turned into a cloth and hung inside a vessel to drain in a circulating atmosphere of about 60°F. The cloth should be a coarse towel which should be thick enough to retain the curd while allowing the whey to drain out. The draining should continue for 18 to 20 hours, and during this time the cream should be scraped 2 or 3 times from sides of cloth to facilitate the separation of moisture. After this it should be turned into a fresh cloth and placed under weight of from 8 to 12 lbs. until dry enough for moulding, *i. e.*, for a period of from 8 to 10 hours. Before moulding salt should be added at the rate of 1½ oz. to 2 ozs., to the quantity.

1.137. *Odinary cheese.*—Strain the fresh milk through a thick piece of cloth into a vat. Raise the temperature of the vat very gradually by letting in steam into the jacket of the vat, while slowly stirring the milk with a stirrer, until the temperature reaches 85°F. Cheese-making, therefore, should not be attempted in very hot weather, when it does not need any heating to arrive at the temperature of 85°F. If the cheese has to be coloured, add the colour at this stage, say, 1 oz. of anotto-fluid for every 10 maunds of milk used. The colouring fluid is to be mixed up with a quantity of the milk in the vat and the mixture put in so as to get a uniform distribution of colour. Then add, gradually, by stirring, one seer of rennet mixed up with water to the 10 maunds of warm milk in the vat. Sufficient rennet is to be used to show some coagulation in less than a quarter of an hour. The room should be shut off from draughts of air at this time. In about half an hour the curd will solidify, and then with two curd-cutting compound knives, cleaned, sharpened, and washed with boiling water the curd is to be cut clean, first with the horizontal knife lengthwise and then with the vertical knife vertically, until little cubical masses of curd are formed in the

whey. Continue to stir these cubical masses while the temperature is slowly increased to 98° or 100°F, two degrees being raised every 5 minutes. When this temperature is reached gradually draw off the whey, and continue stirring briskly, and taking off the whey. Then spread the curd over a cloth to run out all the whey, and afterwards pass the curd through a grinding mill. Then mix salt evenly at the rate of 1 lb. for every 5 maunds of milk used. Then weigh out the salted curd into the hoops or moulds fitted with cheese cloth. The cloth should be taken out from hot water, rinsed before putting it on the hoop and letting curd into it. The temperature of the room at the time the hoops of cheese are put under press, should be about 80°F. The pressure should be slow and repeated at intervals of an hour. Then the cheese is taken out of the mould, the cheese-cloth sewn on, and after smearing the surface with hot waters pressure is applied again. The next day it is taken out and left on a shelf to ripen for 2 or 3 months.

1,138. *Rennet* should be made out of calves not more than a week old. The fourth stomach is cut out turned inside out, wiped dry, turned back and blowed out in the form of a bladder. It should be kept hung up for two weeks in a cool and dark room. Then it is cut up into strips about ¼ inch wide and put in a stone jar containing one seer of water which has been previously boiled and cooled. Sufficient salt is to be added to super-saturate the water. Occasionally stir and rub the strips of the stomach against the water and the sides of the jar. In 3 or 4 days rennet will be ready. 1 seer of this rennet is sufficient for curdling 10 maunds of milk in less than an hour. Strict cleanliness is necessary at every stage.

1,139. Mr. Subba Rao of the Madras Agricultural Department has been successful in making cheese, without the addition of rennet, by adding to the milk the juice of Epicarpurus orientalis. The milky juice of the petiole stalks

of 32 leaves of this tree was used for 4 lbs. of milk. In this connection it may be mentioned that Bengal *gowálás* use the juice of *sheorá* (Trophis aspera) for getting quick curdling of milk. Experiments in cheese-making by the addition of a vegetable ferment, conducted under proper conditions of temperature &c., are likely to important results.

1,140. We may conclude this Chapter by giving a few extracts from Mr. B. C. Basu's Report on the Indian Dairy Commission, dated 19th February 1890.

"As the principles which underlie the separation of cream by centrifugal force, are not generally known in this country, the following description of the "Baby" and the "Windsor" may not be out of place. The principal part of the "Baby" separator is the cylinder, made of the best Swedish steel, placed inside an iron-frame. This cylinder is spun like a top at the rate of 6,000 revolutions per minute by 40 revolutions of the handle, this high speed being attained through the medium of a system of axles and toothed wheels. The milk which flows into the cylinder from a can placed above it is thus made to revolve at an enormous speed, and is at once separated into cream and skim-milk in accordance with the law of dynamics that bodies revolving in a circle fly, or, if restrained, tend to fly away from the centre; and that of two bodies thus revolving, the heavier flies further from the centre than the lighter. Thus, if we put a number of leaden and wooden balls into a cup and give a rotating motion to the latter, the leaden balls will stick close to the inside of the cup, and the wooden ones will collect on the inside of the leaden balls. Now of skim-milk and cream which are the two component parts into which milk naturally separates, the former is considerably heavier than the latter. Thus when milk is made to revolve rapidly the skim-milk being heavier flies further from the centre than the cream, and as both are restrained by the sides of the cylinder, they form two distinct layers inside the cylinder, one within the other.

The milk being thus separated, the skim-milk, which forms the outside layer, is pushed up a narrow tube opening on the inner circumference of the cylinder, into a tin-ring fitted into the top of the cylinder, and from this ring through a spout into a bucket below, and the cream which forms the inner column escapes through a notch at the top of the cylinder into a second tin-ring and from this through a spout into the cream bucket. The flow of the milk into the cylinder is regulated by a float which is placed in a circular tindish which intervenes between the milk and the cylinder.

"The "Windsor" is in principle the same as the "Baby," from which it differs only in one or two details. These are (1) that the revolving cylinder in the "Windsor" is horizontally placed, while in the "Baby" it is vertical, and (2) that the high speed of the cylinder in the "Windsor" is communicated by the handle through two friction rollers on which the axle of the cylinder rests.

"All the modern cream separators are based on the principle of separation by means of centrifugal force, as described above. They may be of any desired capacity. The larger ones have to be driven by steam-power and can separate as many as 150 gallons of milk per hour, while the "Baby" has a capacity of 12 gallons and the "Windsor" of 35 gallons per hour.

"The Victoria churn shown is an end over end churn, and unlike most churns, has no beaters inside. The absence of beaters inside is said to be an advantage, as it allows the churn to be easily washed and cleaned. It may be remarked here that in all dairy operations, cleanliness of utensils is a matter of the utmost importance.

"Mr. Howman gave a series of demonstrations at the Metcalfe Hall. The chief among these are briefly described in the following paragraphs:—

(1). "The first demonstration was intended to be a compe-

titive trial between the English method of butter-making and the native. For this purpose a native dairyman carrying on a large milk trade at Kidderpore was induced to enter the field with Mr. Howman. The proceedings opened by making over 136½lbs. of milk of the same quality to each of the two parties. Mr. R. Blechynden, Secretary to the Agri-Horticultural Society of India, Mr. Irving of the firm of Messrs. T. E. Thompson and Company of Calcutta, and Mr. B. C. Basu, Assistant to the Director of Agriculture, Bengal, superintended the proceedings. Mr. Howman passed his portion of the milk through the "Windsor" separator, and the cream was put aside in a safe place to make it "ripen" and get ready for churning butter on the next day. The native dairyman heated his milk and set it to curdle into *dahi* in earthen pots which were also put aside for the night. On the next day at 12 o'clock several other gentlemen, among whom were Mr. Finucane, Director of Agriculture, Bengal, Dr. Greenhill, Mr. Tremearne, Managing Director of the Great Eastern Hotel, and the Superintendent of the Sailors' Home, came to see the competitive trial. Mr. Keventer placed the cream made on the previous evening into the Victoria churn, and in less than half an hour the churning was complete, and the butter pressed and made. Against this four *goálás* were put to work to churn the *dahi* and get out the butter in the native way. Although no attempt was made to arrive at a comparative idea of the time occupied by each process, the gentlemen who watched the proceedings came to be of opinion that the mere process of butter-making as followed by native dairymen would take full thrice the time as the English process of butter-making from cream. The native dairymen present at the trial seemed to be much interested in the new method and were compelled to own that, apart from other advantages, the English method of butter-making had a decided advantage over their own in respect of the saving of labour. On weighing the two lots of butter, the superiority of the English

method became at once apparent,* its outturn being 6 lbs. 6 ozs., against 4 lbs. 13 ozs. by the native method. The native butter also looked thinner and appeared to contain a larger percentage of water in it than the machine-turned butter. To ascertain this point, it was proposed to carry the trial further by converting the butter from either process into ghee, but during the boiling an accident occurred which put an end to the proceedings so far as the native butter was concerned. The butter from the machine gave 4lbs. 4ozs. of ghee (67 per cent. on the butter), and a residue of only 1 oz. 12 drs. of curd and skimmings.

"As regards the quality of the two lots of butter, Mr. Howman claimed superiority for his own; but on this point the gentlemen present were not unanimous to give any decided opinion.

"The second demonstration was with buffalo milk. It was also intended to be a competitive trial, but the cream which Mr. Howman separated was not kept for butter-making but distributed in small quantities to several European gentlemen, all of whom pronounced the cream to be of very good quality. The native dairyman made butter out of his lot of buffalo milk and obtained 1½ lbs. of butter from 22½lbs. of milk, which is 1lb. of butter to 15lbs. of milk. This shows the very rich quality of buffalo's milk as compared with the cow's.

"The great heat of the Indian plains does not permit the making of cream by the ordinary method of setting the milk in pans; hence this delicious article of food is not at present available in the Indian market. The difficulty of obtaining cream from new milk by means of the centrifugal separators has been now proved, and it is hoped that before

* It should be noted here that the native dairymen would have got a larger yield if they churned the *dahi* early in the morning (as they always do) instead of in the afternoon.

long the European public of Calcutta will have no cause to grudge the absence of this article of luxury from their table.

"Several more trials were made to show the working of the separators. In one case 85lbs. of milk were separated by the "Windsor" in 18 minutes, and the cream when ripe was churned by the "Victoria" and gave 5lbs. 4 drs. of butter (1lb. of butter to 17lbs. of milk); in another 5lbs. of cow's milk was separated by the "Baby" in seven minutes, and the cream was immediately churned into butter. The quantity turned out was 5½ozs. (1 to 30½). The diminished yield was partly attributed to the fact of the cream being churned while yet fresh. To get the maximum quantity of butter, the cream should be ripened, *i. e.*, soured by keeping: sometimes a proportion of butter milk is added to sour the cream.

"*Cheese-making.*—As an all-round dairy animal, Mr. Howman considers the buffalo as superior to any kind of cow —European or native. The experiments which he conducted in Bombay and Madras have led him to entertain this view. From these he found that buffalo's milk contains almost twice as much solids as the average of cow's milk, the increase being mainly in fats and casein. Native experience fully confirms this view. The bulk of the ghee and butter in the Bengal market is made from buffalo's milk, and the Dacca cheese, which is made in the Megna islands, is said to be entirely made from it. Mr. Howman thinks that besides home consumption, buffalo milk cheese may be largely made for export. The Italian cheese, Gorgonzola, is said to be made from buffalo milk, and there is no reason why it should not be made in India. To demonstrate the feasibility of cheese-making in Bengal, Mr. Howman took a small quantity of whole buffalo's milk and had it made into cheese. The milk was set with rennet and the curd pressed in a press which was improvised by perforating the bottom of a small circular tin box into which the curd was placed and pressed down by

weights. It remains now to be seen how the cheese, so far well made, ripens by keeping in the climate of Bengal.

"Mr. Howman was possessed of an idea that probably ghee might be made directly from cream, thus avoiding all the labour and expense of converting the cream into butter as an intermediate product. To test this point, a small quantity of cream (about 8 ozs.) was put into a melting pot over a slow fire, and kept boiling for about half an hour when the curd separated itself from the ghee which was then strained through a piece of muslin. The quantity and quality of the ghee thus made were creditable, but the length of time and the quantity of fuel which was necessary to convert the cream into ghee, as well as the labour and trouble involved in constant stirring of the liquid to prevent it from burning against the sides of the melting pot, appear to preclude the possibility of profitably making ghee directly from cream.

"The above were the most important of the numerous demonstrations Mr. Howman gave at the Metcalfe Hall. The working of the separators and the churn was continued to be shown every afternoon to the public up to the 2nd February, when Mr. Keventer, the Dairy Assistant, left for the Khoolna Agricultural Exhibition. Mr. Keventer worked here for two days, and although the quality of butter he made was pronounced to be very good, the proportion of milk to butter turned out by his machines was very low and created an unfavourable impression in the minds of the spectators as to the efficacy of the machines. Of the three butter experiments he made, the most successful one gave 1 lb. of butter to 32 lbs. of milk, the proportion usually accepted being 1 : 16. In this connexion I may mention that Mr. Keventer pronounced a sample of native-made butter he saw at the Khoolna Exhibition to be the best he had seen in India and quite as good to look at as any European butter. The people present at the Exhibition did not, however, consider the sample as the best of its kind."

CHAPTER CIX.

BACON AND HAM CURING.

FARMERS in Europe and America usually practice the art of ham and bacon curing. The principle consists in adding preserving substances to the meat and allowing time for these to saturate the tissues. This inhibits the growth of bacteria and renders it possible to keep the meat for an indefinite period.

1,142. The carcase of the animal is rolled inside vat filled with water at 180°F. until the hair comes away easily in the hand. Then it is put on a table and the hair removed by scrapers. Then it is hung up above a singing furnace in which it is singed for about a quarter of a minute. Then the carcase is lowered into a cold bath for a second and taken of again and the burnt surface scraped off with hand scrapers. The intestines and offal are then removed and sorted and the carcase after being again cleansed is split down the back, the vertibral column removed, and the two sides including the vertibral column, the head, the feet and the kidney fat, are weighed. This is called the dead weight of the animal. The dead weight of an animal weighing 16 st. is about 12 stone; from this is deducted 2 lbs. for evaporation, &c. and the price is fixed on the net weight. Then the head and feet are completely severed, the kidney, fat and vertibral column removed, and the sides are disconnected and allowed to cool hung up for 6 to 12 hours, according to the time of the year. They are then placed in a refrigerator for 12 hours until the meat registers a temperature of 40°F. The refrigerator must be 38°F for the meat to be cooled down to 40°F. The blade bones are then removed and the sides

trimmed and taken to the cellar where they are laid on a bench and pumped at various points at a uniform pressure of 40 lbs. per square inch with a pickle made of, salt, 50 parts, granulated saltpetre 5, dry antiseptic, *i. e.*, cane sugar (in winter only) 5 parts. To these substances 20 gallons of water are added and stirred till all the material is dissolved. The strength determined by the salinometer should be 95°. If it indicates less add more salt until it indicates 95°. The sides are wiped with a portion of the pickle used for pumping and are then laid on the cellar floor. A mixture of equal quantities of saltpetre and dry antiseptic is then sprinkled over the whole of the inside or cut surfaces, with a sieve. Salt finely ground is then sprinkled over the same surface, and the sides are now permitted to lie in that condition for 7 or 8 days when it will be cured and may then be washed and baled for transport, or the sides may be washed and dried as "pale dried bacon," or they may be smoked and sold as smoked bacon. If wanted in the pale dried state the sides are hung up in a ventilated drying room heated to a temperature of 80°F with a steam pipe, and kept there until quite dry. Smoked bacon is produced by hanging the sides in a smoke store for about 3 days where it is exposed to the smoke and fumes given off by smouldering hardwood saw dust. The smoke store must be well ventilated.

1,143. A simpler method is to make a pickle consisting of 5 lbs. of common salt, ½ lb. of saltpetre and 2 gallons of cold water, to which ½ lb. of sugar may be added. Into this pickle the whole or cut up carcase is kept dipped for 3 days at a fairly uniform temperature of 50°F, and then dry salting is done for 9 days, or in the case of big animals up to 12 days.

1,144. The most important points in the curing of bacon and ham are, (1) cleanliness of all the operations (2) uniformity of temperature of the cellar and (3) evenness of density of the pickle used. Bacon and ham curing is

carried on successfully on European principles by Raja Rampal Sinha of Oudh.

1,145. *Ham-curing.*—If the carcase is cut up into sides or smaller pieces and cured it is called ham. Ham-curing is easier than bacon-curing, though the principle is the same. After the sides have been chilled they are cutup in large pieces which are flung into the pickling used in the preparation of bacon. They are allowed to remain there until the next morning when they are taken out and pressed so that the blood may be entirely squeezed out from the views. They are then laid alternately between layers of salt. Pumping may be done at a low pressure with an antiseptic pickle. The same mixture of antiseptic and saltpetre is spinkled over the cut surface and the whole is covered with salt. After 3 days the hams are pressed again so as to squeeze out any blood remaining in the sinews. They are then laid down and covered with fine salt and left in this position for 15 days if pieces weigh about 15 lbs. They require a day for every pound weight to cure, but left for a week at least even if the weight is less than 7 lbs. Then the pieces are dried and stored.

1,146. Here is another recipe for curing ham or sides of bacon :—Pour 4 gallons of boiling water to ½ a bushel of salt and ¼ lb. of saltpetre. Stir till the mixture dissolves. When cold add 1 lb. of treacle. Put the sides in this brine and keep it under with heavy stones. Turn it every 2 days and let it remain in pickle for 10 days or a fortnight according to thickness. Large hams require 1 month to five weeks curing. Then simply rub each piece well with dry salt. Place piece upon piece on charcoal. Leave them in this way in 6 weeks. Then rub a little more salt and hang up. For hams use treacle or sugar and some saltpetre with the salt and rub well, for bacon salt alone does. Drip occasionally with their own brine. After 6 or 8 weeks take up to dry and when dry put up in bags to keep out vermins.

1,147. For curing *mutton hams* the following recipe has been found very reliable :—

Water	1 gallon.
Black horse-salt...	3 lbs.
Saltpetre	¼ lb.
Gur	1½ lbs.
Mixed spices	1 ounce.
Juniper berries	1 „
Pearl ash	¼ „

The hams should remain in this pickle for 3 weeks, being slightly agitated daily, after which they can be smoked.

CHAPTER CX.

CURING SHEEP AND OTHER SKINS.

IF the skin is dry, soak it in water until it is quite soft. Scrape off any fat that is present, placing the skin on a scraping board and using a scraping knife with two handles for the purpose. Then wash the skin well in warm soap water; wring out but do not rinse. Then leave the skin for 2 days in the following mixture. To 5 gallons of soft water add 3½ lbs. of common salt and stir the mixture well until the salt dissolves completely. Then add 1¼ lbs. of commercial sulphuric acid and stir again. This mixture will smart the hand but do no harm. Put the skin in this mixture, then rinse it in cold water, wring out as dry as possible, and then hang it in shade to dry. During drying the skin should be rubbed between the knuckles as when washing clothes, pulled, stretched in every way and scraped. Any hard parts may be reduced with pumice stone, though scraping with a knife also answers. As a finish, dust a little whitening

over the skin and rub this all over with pumice stone. During stretching and scraping, the wool should be combed out and not left unkempt till the skin has dried.

1,149. Curing is also done with a mixture of alum, eggs, flour and sugar laid thick over the fleshy portion of the skin after the preliminary scraping and washing. This is how soft kid-skins are made.

PART VI.

Insect and Fungus Pests.

CHAPTER CXI.

GENERAL REMEDIES AGAINST PESTS AND PARASITES.

APPLIANCES.—In America the dust of dry Pyrethrum leaves and various patent powders are largely used against all insect-pests. A hand-duster (Fig. 74), or one of the patent bellows, sold by Messrs. Henderson & Co. of New York, may be used for dusting all sorts of insecticides or fungicides. In Fig. 75 three different forms of bellows are



FIG. 74.—NORTON'S PLANT DUSTER.



FIG. 75.—WOODASON'S BELLOWS FOR POWDER AND FLUID.

illustrated: one for spraying, another for vaporising and the third for dusting, insecticides or fungicides.

1,151. For spraying Kerosine Emulson or Bordeaux mixture, one of the many forms of Knapsack pumps (Fig. 76),



FIG. 76.—THE ECLAIR VAPORISER.

may be used. Fig. 77 represents the general manner in which these and other spraying machines are used. The Eclair Vaporiser represented in fig. 76 is provided with a



FIG. 77.—MANNER OF USING SPRAYING MACHINES.

handle which the man distributing the liquid keeps working. Air and the liquid are forced out of the same orifice by this action, and the result is the distribution of the liquid in extremely fine particles over a large space. Each time about 30 lbs. of liquid can be charged, and three such charges will be enough for sprinkling a solution over a whole acre of land in the course of a few hours. The vaporiser

should be thoroughly cleaned and dried after it has been used, and before it is put away. Very large spraying machines and vaporisers mounted on carts and intended for spraying orchards and large plantations, are constructed, but Henderson's Atomising Syringe and the Eclair Vaporiser will be found sufficient for the needs of Indian cultivators. The Lenox Sprayer represented in fig. 77 uses up more liquid than the Eclair Vaporiser, and it is, therefore, not adapted for strong irritants like Sulphate of Copper which should be applied in very fine sprays.

1,152. An appliance which is very useful for singing insects on trees and shrubs, is the Asbestos torch (Fig. 78). The asbestos ball is saturated with kerosine oil and lighted and the lighted torch passed over infested branches and leaves. Tea and coffee bushes may be given a light singing in January to kill eggs and spores of parasites.

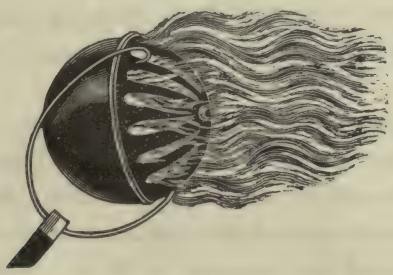


FIG. 78.—ASBESTOS TORCH.

1,153. The following general directions should be borne in mind in *storing grains*. (*a*) The buildings used should be close. (*b*) The bins used should be tight-fitting, allowing access neither of air, nor of light, nor yet of weevils and moths. (*c*) The granary and its surroundings should be kept clean. (*d*) Refuse grains should be destroyed and not left about. (*e*) Grain should be dried thoroughly before it is stored.

(*f*) Storing can be done between thick layers of well dried *neem leaves*, or in tarred vats lined completely with dry straw. (*g*) Napthaline powder, half a tea-spoonful for every 10 cubic feet of space once every 15 or 20 days, or 1 ounce to every 100 bushels of grain, also keeps out insects. (*h*) Carbon-bisulphide, however, is the best substance to use for protecting grains stored in godowns. The gas of Carbon-bisulphide being heavy, sinks and the liquid can be thrust into the grain-store from the top. The use of a *Quarantine bin* is recommended by Mr. L. O. Howard of the United States Department of Agriculture. Into this all seeds and grains are put in bags as they come in and are disinfected by Carbon-bisulphide, before they are stowed away. The quantity of Carbon-bisulphide used being 1½ lbs. for every ton of seed or grain. (*i*) Hymenopterous insects belonging to the order Chalcididæ prey upon and destroy insects injurious to grains and their presence in godowns should be encouraged. (*j*) Salted sacks, *i. e.*, sacks dipped in a ten per cent. solution of common salt, and afterwards dried, have been found very useful in keeping out weevils from grains stored in them. (*k*) For small quantities of vegetable and other seeds that may be easily stored in bottles, a drop or two of mercury shaken up with the grains in the bottles, are found most useful in keeping out insects. Mercury should not be used for storing grains meant for food and not for seed. Carbon-bisulphide can be had of Messrs. Waldie & Co. of Calcutta for 12 annas a lb. in quantities of 10 lbs. or more.

1,154. For *boring insects* and other pests which can be reached only by smoke or gases, Hydrocyanic acid gas may be used by means of a pair of patent vaporising bellows. This gas is generated by using 1 ounce of Potassium Cyanide with 1 ounce of Sulphuric acid and 3 ounces of water placed in the glazed receiver of the bellows. The gas generated by the above quantities will be sufficient for 150 cub. ft. of space. Sometimes tents are erected over valuable shrubs and

small trees, and the insects spoiling them destroyed by means of the gas generated inside the tent. Smoke from ignited *mahua* seed oil-cake at the first appearance of an insect-pest has been found efficacious. One and a half maunds of this cake per acre burnt wind-ward are quite sufficient. The generation of Chlorine gas wind-ward has been also found efficacious in scaring away locusts, grass-hoppers and hispas. Common salt (375 parts), black oxide of manganese (150 parts) and sulphuric acid (300 parts), are used for the generation of this gas. The above quantities of salt and black oxide of manganese are shaken up with 300 parts of water and then the sulphuric acid is poured on the mixture, slowly from one side.

1,155. For *scale-insects, resin-wash* is particularly useful. It is made by boiling together for 3 hours in a covered vessel 5 lbs. of caustic soda, 15 lbs. of resin, and sufficient water. Then the mixture is diluted with water by gradually bringing it up to 100 gallons. It is then to be strained through canvas, and when quite cool applied with an Eclair Vaporiser. For scale-insects the best remedy is the *lady-bird* which feeds on them.

1,156. As an *insecticidal paint* for the trunk and main branches of trees that are spoilt by insects (mainly scale-insects), the following is recommended. Boil 2 lbs. of sulphur and 1 lb. of stone-lime in 2 gallons of water for 1½ hours. Then add 3 lbs. more of stone-lime and boil for another ½ hour. Make up with boiling water to 2 gallons and add enough fine flour or fine clay to the mixture to make it like thin paint.

1,157. For *aphides* squirting or spraying of a solution of soft soap mixed with some bitter substance such as a decoction of catechu or of quassia, answers very well. But the *Calcium Sulphide wash* is the best for aphides. It is prepared in this way. Unslaked lime 18 seers, Sulphur 9 seers, and Salt 6¾ seers are to be mixed up in the following manner.

A fourth part of the lime is slaked and boiled for 2 or 3 hours with the sulphur in 25 seers of water. The remainder of the lime is then slaked and added with the salt to the hot mixture, The whole is boiled for another half hour or an hour and diluted to 400 seers. The fluid is applied lukewarm when the plants are not in active growth.

1,158. When *animals* are troubled with ecto-parasites, such as tick, lice, fleas, itch-mite &c., they are dipped in a reservoir containing an insecticidal solution. The following mixture may be used, as a *cattle-dip* :--

1½	lbs. of arsenic
3	lbs. of soda.
3	lbs. of soap.
100	gallons of water.

Kerosine emulsion, *i.e.*, kerosine oil, shaken up with soap solution, or with butter-milk (*ghol*) and diluted with 100 times as much water, may be also rubbed into the skin of animals suffering from ecto-parasites. Kerosine emulsion is a very potent remedy against all soft bodied insects.

1,159. Of *patent insecticides*, may be mentioned "Niquas," which has been favourably reported upon by Mr. P. Lancaster, Secretary to the Agricultural and Horticultural Society of India. While killing insect-pests of all kinds, it has no injurious effect on leaves of plants, such as is produced by kerosine emulsion and ordinary arsenical mixtures. One gallon of Niquas can be mixed up with 80 to 100 gallons of water, and the solution applied with a spray-pump. The price is Rs. 5 per gallon. The manufacturers are Messrs. Corry and Co., Bonded Chemical Works, Shad Thames, London.

1,160. *Fungicides.*—The *Bordeaux mixture* is the standard fungicide, but as it combines well with arsenical poisons, and as a combined spray of Bordeaux mixture with an arsenical poison, such as *Sankhya*, London Purple, or Paris Green, acts both as an insecticide and as a fungicide, the combined mixture may be used when there is any occasion for it. 1 lb.

of one of the arsenical poisons should be mixed up finely powdered with 160 gallons of Bordeaux mixture. The Bordeaux mixture is prepared by adding to 40 gallons of hot water, 6 lbs. of powdered sulphate of copper and 4 lbs. of powdered unslaked lime. The mixture should be always neutral. If there is an excess of sulphate of copper, it is apt to injure the foliage. To see if the mixture has been properly made or not, the clean blade of knife is to be dipped into it for a minute. If the knife is untarnished the mixture is all right, but if the knife is stained a coppery colour, more milk of lime is to be added.

1,161. As an all round combined fungicide and insecticide, may be also mentioned the sulphur, lime and salt wash. Take 40 lbs. of unslaked lime, 20 lbs. of sulphur, 15 lbs. of salt, and 50 gallons of water. Boil the sulphur with 10 lbs. of lime for not less than 1½ hours or until the sulphur is thoroughly dissolved, in a strong iron (not a thin copper) boiler, when the mixture will be a light amber colour. The remaining 30 lbs. of lime is to be slaked with hot water and when thoroughly slaked but still boiling, 15 lbs. of salt are to be added. When this is dissolved, the whole should be added to the lime and sulphur in the boiler, and the combined substances boiled for half an hour longer, when water, to make the whole up to 50 gallons, should be added. Then straining should be done through wire sieve and the mixture should be well stirred before use. After using this mixture, the spraying machine must be thoroughly washed with hot water.

1,162. Another standard fungicidal solution is the *Eau Celeste*. This is made by mixing 1 lb. of sulphate of copper with 2 gallons of hot water. When cool 1½ pints of commercial ammonia (strength, 22° Baumé,) are to be added. The solution is to be kept tightly corked and when it is required for use, it should be diluted with 20 gallons of water. The Eclair Vaporiser may be used in spraying both the Eau Celeste and the Bordeaux mixture.

1,163. Against insect-pests generally, there are many *natural enemies*, such as dragon-flies, ichneumon-flies, lady-birds, spiders, ants, bats, frogs, lizards, and certain birds, such as, starlings, king-crows, domestic fowls, thrushes, shrikes, drongos, rollers, wood-peckers, tit-mice, jays, lap-wings, nut-hatches, bee-eaters and plovers. Crows are very destructive to unripe grains of maize, though they eat grubs also. Of all the birds mentioned, starlings (*shálik*) are the *best friend of the farmer*. As a rule, birds that are good to eat (such as, pigeons, doves, bagaries and sparrows) or have very fine and attractive plumage (such as, linnets and parrots), are destructive of grain. As these are constantly hunted by man, they are naturally kept down. Sparrows, and linnets (*bábui*) perhaps do the greatest amount of damage. The following recipe may be tried *against small birds:* A quantity of wheat is to be crushed and mixed up with Plaster of Paris, flour and sugar. This mixture should be kept out near the fields of ripening paddy, &c., out of the reach of domestic fowls. The birds partaking of this food die, but not immediately, and so other birds not suspecting the cause of their death go on eating the mixture.

1,164. *Lighting fires* at night or hanging up lanterns in plantations with troughs of water (to which a little kerosine oil may be added) underneath, is a good means of attracting and destroying insects.

1,165. *Umbelliferous spices* (*sulpa*, coriander, &c.) repel insects and these may be grown here and there in the midst of and around crops that are particularly subject to the attack of insects, such as, cabbages, cauliflowers, brinjals, &c.

1,166. *Ichneumon flies* are largely attracted by flowers of *arahar* and country *sim* (Dolichos lablab). These may be grown round a plantation of sugar-cane, as ichneumon flies are known to destroy sugar-cane borers.

1,167. Sugar-cane, maize, and other crops may be

protected from such pests as jackals, pigs, deer, &c., by a *hedge* of prickly pear, agaves, thorny safflower, &c.

1,168. *Free irrigation* is a great preventive against cut-worms, white-ants, crickets and grasshoppers. They come out of their holes and hop away as soon as a field is thoroughly irrigated.

1,169. *Thorough preparation* of land and hurdling in of fowls (scratchers) in ploughed up fields before sowing, are also good preventives.

1,170. *Against rats*, the Scientific American recommends the following remedies :—

(1) When a house is infested with rats which refuse to be caught by cheese and other baits, a few drops of the highly scented oil of rhodium poured on the bottom of the cage will be an attraction which they cannot refuse.

(2) Place on the floor, near where their holes are supposed to be, a thin layer of moist caustic potash. When the rats travel on this, it will cause their feet to become sore, which they lick, and their tongues become likewise sore. The consequence is that they shun the locality, and seem to inform all the neighbouring rats about it, and the result is that they soon abandon a house that has this preventive.

(3) Cut some corks as thin as wafers, and fry, roast or stew them in grease and place the same in their track ; or a dried sponge fried or dipped in molasses or honey, with a small quantity of bird lime or oil of rhodium, which will fasten to their feet and cause them to depart.

(4) If a live rat be caught and smeared over with tar or train-oil and afterwards allowed to escape in the holes of other rats, he will soon cause all to take their departure.

(5) If a rat be caught and a small bell be fastened around his neck, and allowed to escape, all of his brother rats as well as himself will very soon go to some other neighbour's house.

(6) Take a pan, about twelve inches deep, and half fill it

with water; then sprinkle some bran on the water and set the pan in a place where the rats most frequent. In the morning you will find several rats in the pan.

(7) Two parts common squills (well bruised) and 3 parts of finely chopped bacon are made into a stiff mass, with as much meal as may be required, and then baked in small cakes, which are put around for the mice to eat."

1,171. The best natural enemy of the rat is the mongoose or ferret. Snakes also devour a great quantity of rats, and when not poisonous, they are one of the best friends the farmer has.

CHAPTER CXII.

AGRICULTURAL ZOOLOGY.

BEFORE introducing the reader to the principal insect-pests that cause damage to agricultural crops, it is desirable that a bird's eye view of the different orders of animals should be given, in a systematic manner, which may enable him to distinguish insects from among the various groups of animals that are popularly known as worms

and vermins. The following zoological schemes have been drawn up with special reference to insects :—

Scheme No. 1.

Animal Kingdom.

- I. Sub-kingdom Protozoa
  - A. Gregarinidæ
  - B. Rhizopoda (*e.g.* Amœba, foraminifera, radiolaria).
  - C. Infusoria
- II. Sub-kingdom Cœlenterata
  - A. Hydrozoa (*e.g.* Jelly fish, zoophytes, sponges).
  - B. Actinozoa
- III. Sub-kingdom Echinodermata (*e.g.* Starfishes Sea-urchins, Sea-lilies, Sea-cucumbers)
- IV. Sub-kingdom Annulosa
  - (*a*) Vermese or true worms
    - A. Tape-worms, or, Tæniads
    - B. Fluke- worms.
    - C. Leaf worms.
    - D. Thorn-headed worms.
    - E. Hair-worms.
    - F. Nematodes or round worms.
    - G. Earth-worms.
    - H. Leeches.
  - (*b*) Arthropoda or jointed footed worms.
- V. Sub-kingdom Mollusca (*e.g.* Oyster, mussel, cockle, periwinkle, whelk, snail)
- VI. Sub-kingdom Vertebrata
  - A. Pisces
  - B Amphibia (*e.g* newts, frogs, toads)
  - C. Reptilia (*e.g.* Tortoise, lizards, snakes, crocodiles).
  - D. Aves
  - E. Mammalia

Scheme No. 2.

SUB-KINGDOM IV (*b*).

Arthropoda.

- I. Crustacea (*e. g.* Cray fishes, lobsters, crabs)
- II Arachnida (*e. g.* spiders, scorpions, ticks, mites)
- III. Myriapoda (centipedes and millipedes)
- IV. Insecta.
  - Metabola
    - A. Hymenoptera (*e. g.* bees, wasps, ants, ichneumons)
    - B. Coleoptera (*e.g.* Carabidæ or Carnivorous ground beetle, Ditiscidæ or water-beetles; Sylphidæ or burying beetles; Dermestidæ or Bacon beetles; Scrabididæ or cockchafers; Elatiridæ or Click-beetles (wire-worms); Tenebrionidæ or meal beetles; Curculionidæ or weevils; Cerambicidæ or woodborers; Chrysomelidæ or leaf and flea-beetles; and Coccilinidæ or lady-birds.)
    - C. Lepidoptera (butterflies and moths).
    - D. Diptera (Flies and mosquitoes).
  - Hemi-metabola
    - A. Hemiptera or Rhynchota
      - *a.* Hemiptera heteroptera (Bugs, lice)
      - *b.* Hemiptera homoptera (*e. g.* cicads, plant, lice, scale insects)
    - B. Orthoptera (Cockroaches, ear-wigs, crickets and grass-hoppers)
    - C. Neuroptera (Dragon flies; white ants.)
    - D. Thysanoptera (Thrips)
  - A-metabola
    - Thysanura (Scale louse)

1,173. A short description of each of the above groups of animals, mainly bringing out the meaning of the various

terms used in the above scheme, will be of some use in getting a fairly intelligent idea of the classification of the animal kingdom given in the scheme.

1,174 *Protazoa.*— The characteristic features of this class of animals are, they are simply little masses of protoplasm, without definite organs or a definite body cavity. They have no nervous, digestive or circulatory systems. The protoplasm is not surrounded by a cell-wall as in the case of vegetable cells and the protozoa are therefore able to throw out pseudopods *i. e.,* prolongations of the protoplasmic mass of which their body is composed, when they notice any food substance before them. Thus they possess volition which characterises even the lowest member of the animal kingdom. Looked at under the microscope these lowest animals present at least three common characteristics: (1) they are nucleated masses of protoplasm; (2) besides the nucleus they have a contractile vesicle, a sort of rudimentary heart; (3) the masses of protoplasm are full of granules. The Gregarinidæ and Rhizopoda are reproduced by fission at the nucleus. Foraminifera are encased in shells of calcium carbonate,—a particle of chalk being a mass of such shells. Radiolaria are encased in shells of silica. They have a distinct mouth. Infusoria also have a distinct mouth, but no stomach. They multiply not only by fission but also by conjugation and gemmation: Infusoria grow abundantly in rotting animal matter in presence of water. They are either ciliated or flagellated.

1,175. *Cœlenterata.*— These have both mouth and a body-cavity; but no nervous system, no circulatory organ, no blood. They have distinct stinging organs. Reproduction takes place both sexually and by segmentation. They usually live in colonies (*e.g.* sponges and corals). They are sometimes polymorphic in character, *i. e.* possessing more than one form and the same form repeats itself at regular succession by a process which is known as alternation of generation.

The colonial animals of this group live in common skeletons or houses made of calcium carbonate or silica.

1,176. *Echinodermata.*—In this group the body cavity is distinct from the alimentary canal. The body cavity is circulatory, belonging to the water-vascular system of circulation. There is a distinct radiate nervous system. The body is bilaterally symmetrical. Examples, star-fishes, and sea-urchins.

1,177. *Annulosa.*—The bodies of these animals are in segments. They are never radiate, but more or less worm-like. Locomotary organs which are bilaterally symmetrical are present in the arthropoda, but not in true worms (*Vermese*). Reproduction of *Vermese* is either hermaphrodite, or conjugal, or parthenogenetic, or by simple gemmation. They have no true blood, water-vascular system being present. They have a ventral nervous system which is not radiate as in the case of Echinodermata. Most of the Vermese are parasitic. Domestic animals and birds often suffer from tape worms. Thes ethrow out segments (proglottides), a chain of such segments, finishing up with a head which is provided with hooks and 4 cup-shaped suckers attached to the stomach or intestines of the host, may be as long as 90 ft. Each proglottis has both male and female eggs, so that if one of these is swallowed by an animal it is enough for the reproduction of the parasite. The adult form usually occurs in the dog and only a cystic form in man, or sheep, or ox ; and the superstition common among Hindus and Mahomedans that a dog is an unclean animal is a very useful superstition in as much as it helps to reduce the possibility of tape-worm in man. In the nematodes or round worms the male and female are separate and the body is unsegmented. Like tape-worms they are provided also with spines and suckers at the anterior end.

1,178. *Oligochætæ* or earth-worms have segmented bodies, the number of segments being 100 or more and they have four rows of false feet or pads. They have no suckers to

their mouth, but the alimentary canal is divided into distinct portions, such as pharynx, œsophagus, proventiculis, gizzard, intestine and anus. The blood vessels are two in number and united in heart-like sacs, but it is not true blood that flows through these vessels, though it is a corpusculated fluid. The nervous system consists of a set of two ganglia above the œsophagus and two below. There are two pairs of testes.

1,179. *Hirudinæ* or leeches have a double chain of ganglia united by longitudnal cords and forming a collar round the gullet. The mouth of a leech is triradiate *i. e.*, having three jaws. In some species the jaws are provided with teeth. There are two suckers, one at the anterior end and the other at the posterior end. The stomach is provided with lateral sacs. There are 9 pair of testes, one vas deferens and a protrusible penis. The female organ is inconspicuous, but the females have 2 distinct ovaries and an oviduct.

1,180. *Arthropoda* including the lobster class, spider class, centipede class and insect class of animals, have a definite series of rings, the integument being hard and often chitinous; each arthromere or ring has its tergum and sternum sides. The rings dispose themselves into two distinct sections, the head and the thorax going to form one section, called the Cephalothorax and the abdomen another section. The appendages are hilateral. The blood is true blood, but there are no red corpuscles. The heart is situated longitudinally on the back. There is a double chain of ganglia at the ventral side, the foremost pair of ganglia being above the gullet and they may be assumed to correspond with the brain of higher animals. Metamorphosis takes place by ecdysis or moulting.

1,181. *Crustacea.*—This class of arthropoda have more than 8 feet some of which are abdominal. The respiration is aquatic either by means of gills or by the whole surface of the body. There are twenty pairs of antennæ.

1,182. *Arachnida* are characterised by having 8 feet. The

respiration is aerial, by means of tracheæ or of pulmonary chambers: The head and thorax are amalgamated. There are no antennæ and no abdominal legs, all the 8 legs proceeding from the cephalothorax.

1,183. *Myriapoda* have a larger number of feet than even the Crustacea. The head is quite distinct, the thorax and the abdomen being amalgamated into one uniform chain of rings. There is a pair of antennæ Respiration is by means of tracheæ ending in distinct spiricles.

1,184. *Insecta.*—This order will be more fully described in the next Chapter.

1,185. *Mollusca.*—These are soft-bodied animals, usually provided with a covering shell. The body is without any distinct segmentation. The nervous system consists either of a single ganglion or scattered pairs of ganglia. Heart and breathing organ are sometimes absent. The Mollusca are classified under two divisions, *viz.*, Mulluscoida and Mollusca proper. The Molluscoida have their heart either entirely absent or quite rudimentary. The nervous system consists of one ganglion or a pair of ganglia. Brachiopoda, the bodies of which are enclosed in a bivalve shell and Polyzoa are examples of this Division. The Mollusca proper have a well-developed heart with two chambers. This division consists of univalve and bivalve animals. To the former belong the Cephalopoda (*e.g.* ammonites) and Gastropoda (*e.g.* whelks). To the latter belong Lamellibranche (*e.g.* oysters and mussels).

1,186. *Vertebrata.*—These are characterised by the possession of an ento-skeleton definitely segmented. The nervous centres are dorsal and shut off from the general body-cavity. The limbs are away from the nervous centres and never more than four. In most cases the adult has a vertebral column.

1,187. *Pisces.*—Fishes are characterised by possessing a gill; their heart consists of only one auricle and one ven-

tricle; their blood is cold, and the only limbs they have are fins.

1,188. *Amphibia.*—Frogs, toads and water-lizards or newts breathe first by gills and afterwards by lungs or by both lungs and gills. The skull has two condyles; the heart has two auricles but one ventricle, their limbs are never fins.

1,189. *Reptilia.*—These include the tortoise, vipers, lizards, and crocodiles, also the extinct saurians, such as Pterodactyle, Ichthiosaurus, Pleseosaurus &c. Respiration is never by gills; the blood is cold; the skull has only one condyle; the integumentary covering consists either of scales or plates, but never of feathers.

1,190. *Aves.*—Birds have their lungs connected with air-sacs; the heart is four-chambered as in the higher vertebrata; the blood is very warm which facilitates brooding; their bodies are covered with feathers; the forelimbs are modified in the form of wings; the skull has only one condyle; the eye-balls are protected by the membrana nictitans. Birds are classified as,—(*a*) Runners (*e.g.* ostrich); (*b*) Swimmers (*e.g.* ducks, penguins, gulls, petrels); (*c*) Waders (*e.g.* cranes, herons, snipes, curlews, plovers); (*d*) Scratchers (*e.g.* fowl, pigeon, pheasant, grouse); (*e*) Climbers (*e.g.* parrot, cuckoo, wood-pecker); (*f*) Perchers (*e.g.* crows, finches, linnets, larks, thrushes, swallows, kingfishers); and (*g*) Birds of prey (*e.g.* owls, hawks, eagles, kites, vultures).

1,191. *Mammalia.*—The lungs are without air-sacs; the bodies are covered with hair or wool; the skull has two condyles; the animals have mammary glands. Mammalia are classified under two heads, *viz*, Non-placental (*e.g.* Kangaroos), and Placental. Of Placental animals the following groups may be mentioned:

(*a*) Cetacea (*e.g.* whale and dolphin);
(*b*) Ungulata (*e.g.* horse and ass and hog);
(*c*) Ruminantia (*e.g.* oxen, deer, sheep and goats);
(*d*) Pachydermata (elephant and rhinoceros);

(*e*) Carnivora (*e.g.* seal, walrus, jackal, dog, bear, wolf, fox, tiger);

(*f*) Rodentia (*e.g.* hare, rabbit, porcupine, beaver, rat, mouse, and squirrel);

(*g*) Insectivora (*e.g.* mole and hedgehog);

(*h*) Edentata (*e.g.* ant-eater);

(*i*) Cheiroptera (*e.g.* bat);

(*j*) Bi-mana (*e.g.* monkey and man).

CHAPTER CXIII.

INSECTS.

THE *Insecta* are characterised by the possession of 6 legs on thorax. The head, thorax and abdomen are distinguishable. There is one pair of antennæ. The thorax is distinguishable into three distinct segments, called respectively the pro-thorax, the meso-thorax and the meta-thorax, and as there is the sternal and the dorsal or notal side to each segment, the wings are distinguished as meso-notary or meta-notary, as the case may be. The heart, as in spiders, consists of 8 chambers, and there are two opposite currents distinguishable. The spiricles are on the abdominal segments only.

1,193. *Hymenoptera.*—These have a long proboscis *i. e.*, a sucking or lapping organ; the ovipositor of the female is usually a stinging organ as well. There are four wings with few veins. The wings are apparently naked but frequently

clothed with short, scattered bristles. Larvæ generally footless ; pupæ inactive. There are some species of Hymenoptera which remain without wings in one or both sexes. Neuter ants are wingless, and even the male and female ants get wings for a little while only. There is one class of Hymenoptera, the ovipositors of which instead of being adapted as stinging organs, are specially adapted as boring instruments. The Tenthredinidæ or saw-flies come under this class. No injurious insects coming under this class have been noticed in India, though the turnip saw-fly, the corn saw-fly, the gooseberry saw-fly, are common pests in Europe. Of the stinging class, parasites belonging to the three families Formicidæ (ants), Ichneumonidæ (blue-bottles) and Chalcididæ, are fairly common in India. Ants, bees and wasps, living in communities and exhibiting wonderful intelligence, are very interesting insects to study ; but they can be hardly regarded in the light of parasites. Ants do more good than harm in eating up grubs of parasites, and specially in capturing and destroying aphides and tunnel making grubs. Ants do occasionally spoil a crop of potatoes by burrowing holes in them and eating up the starch. They are also found attacking seedlings which are usually rich in glucose, *e. g.*, seedlings of brinjals and cabbages. Ichneumon flies which are like slender and small wasps in appearance, have very prominent ovipositors. They are usually helpful to agriculture being parasitic on a number of wild caterpillars, *e. g.*, Pimpla punctator which is a long bodied yellow and black wasp-like insect with a very prominent trifurcated hairy ovipositor. Pteromalus Oryzæ (Fig. 65 *a*), is a minute copper-green ichneumon which may be seen in rice godowns, and which is believed to be parasitic upon wheat and rice weevils. The largest number of Indian Hymenoptera helpful to agriculture belong to the family Chalcididæ. Their ovipositor is prominent, they have wings with very few veins; their habits, as a rule, are parasitic. Cotesia Flavipes (Fig.

65 *b*), is a minute chalcid fly which is parasitic upon the



FIG. 65.—HYMENOPTERA.

(*a*) Pteromalus oryzæ. (*b*) Cotesia flavipes.
(Both magnified.)

sugar cane, sorghum and brinjal borer (Chilo simplex). It is very effective in keeping this destructive borer in check. The other chalcid insects collected and described by the authorities of the Indian Museum are nearly all parasitic on tea or coffee plants. Platygaster oryzæ, a minute flylike four-winged insect, which attacks the Cecidomyia oryzæ, belongs to another family of Hymenoptera.

1,194. *Coleoptera* (beetles).—These are also four-winged insects, the first pair or elytra of which are horny or leathery wholly or partly covering the membranous hind-wings when closed, and meeting down the back in a straight suture. The larvæ are either with or without legs ; the pupæ are inactive Occasionally they are wingless (*e. g.* glow-worms) or with elytra soldered together. Weevils have branched antennæ.

1,195. Nearly half the insects known are beetles ; it being more interesting to collect beetles, they are better known than any other order of insects. The larvæ of most beetles live on vegetation and they are very destructive, as a rule. Some are carnivorous, such as Dermestes, living on other animals or on flesh. Others feed on dung and other refuse matters ; others again such as the larvæ of cockchafers live on roots of plants ; and some live in long galleries in the solid wood of trees, feeding on the substance of the wood.

1,196. Of carnivorous beetles may be mentioned the following :—(1) Cicindela sexpunctata (Fig. 66*a*) called in Bengali *Dhámsá-poká*, which is a tiger-beetle (Cicindelidæ), devours Hispa ænescens and Leptocorisa acuta. The head of this insect is large; eyes very large and prominent; mandibles large and sharply pointed and armed with several prominent teeth. The elytra are spotted and long. The size is about ½ an inch in length. (2) Calosoma orientale which is a ground-beetle (carabidæ), an active black beetle, about the size of a small cockroach ; it feeds on other insects, and has been reported as very useful in the Punjab in destroying young locusts. (3) Trogosita mauritanica, a small brown beetle which feeds on Tineid moths which are a granary pest. But in its larval stage the Trogosita does some injury to stored wheat. (4) Dermestes vulpinus (Fig. 66 *b*), called in Bengali *Kán-kutur,* the larvæ being called, *Shorè-poká,* is a dark coloured beetle, about ¼″ in length with hairy larvæ, which preys on silkworms and spoils cocoons, by feeding on the chrysalids. (5) Lady-birds (cocoinelidæ) called in Bengali *Pedo-poká,* are hemispherical beetles often brilliantly coloured, which are helpful in devouring scale-insects (coccidæ), plant-lice (aphidæ) and other insects. There is one member of this family of beetles, however, *viz.*, Epilachna viginti-octo-punctata (Fig. 66 *c*) which defoliates pumpkin vines, and brinjal plants. Of *scarabidæ* or dung-beetle, may be mentioned here, the Catharseus sabæus (*gubrè-poká*).

1,197. Of *warehouse beetles,* may be mentioned the following : (1) Silvanus surinamensis belonging to the family Cucujidæ, a little brown beetle, with active white grubs, which has been found destroying stored sorghum seed and biscuits. It is also to be seen in date fruits bought in the Calcutta bazaars. (2) Æthriostoma undulata, belonging to the family Dermestidæ, a little brown beetle with white hairy grubs, which are said to be destructive to wheat stored in godowns.

(3) Rhizopertha pusilla, belonging to the family Ptinidæ, a minute brown beetle, commonly found in warehouses, attacking wheat, sorghum seed and biscuits. (4) Calandra oryzæ, *Chèlè-poká*, belonging to the weevil (Curculionidæ) family, is the most destructive of all warehouse pests. It is a very small dark brown beetle with a long snout and jointed antennæ. The larvæ live inside the grains of rice, wheat, maize, sorghum, etc. (5) Bruchus chinensis belonging to the family Bruchidæ is a small brown beetle which is very destructive to stored gram, *arahar* and other pulses. The larvæ are little white grubs which live in the pulse seeds. (6) Bruchus emarginatus is a large grey weevil which destroys stored peas.

1,198. Of *boring and tunnelling beetles* may be mentioned the following: (1) Oryctes rhinoceros belonging to the family Dynastinæ (Goliath-beetles or *mál-poká*) is a very large black beetle with a protuberance on the upper part of its head something like the protuberance on the head of a rhinoceros, which damages cocoanut trees by cutting large holes in them through the young leaf shoots. (2) (Rhynchophorus ferrugenous, or (*Chinrè-kota*) and (3) Sphœnophorus planipennis are two weevils which also bore into the trunks of cocoanut and date palms. (4) The flattened legless larvæ of various species of beetles belonging to the family Buprestidæ, tunnel into timber and stems of various plants. (5) The Bamboo *ghun* (Dinoderus sp.) and other *ghun* insects are also minute beetles belonging to the family Ptinidæ. Dinoderus minutans is the commonest perforator of ripe sugar-cane. (6) The mango fruit weevil, Cryptorhynchus mangifera (Fig. 66 *d*) is also a tunneller. (7) Platydactylus sexspinosus, belonging to the family Scolytidæ, is a small brown beetle, which tunnels into the stalks of paddy plants. (8) The Xyloborus perforans or *Beru-poká* of sugar-cane is a boring beetle. (9) The sweet-potato weevil (Cylas formicarius) may be also mentioned among this class.

1,199. Of *beetles destructive to roots and leaves* may be mentioned the cockchafers or *korá-poká* (Melolonthini). The curved fleshy grubs may be seen destroying the roots of plants and the black or brown imagoes may be seen at night feeding on leaves from March to June. There are two species of Melolonthini that we have at Sibpur. The black one

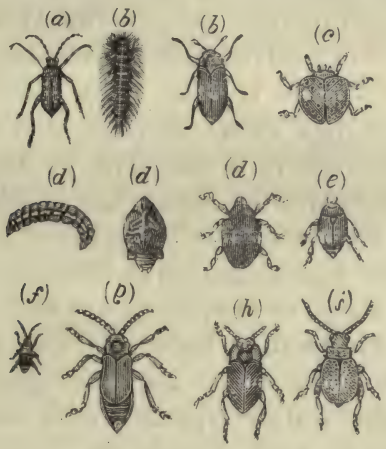


FIG. 66.—COLEOPTERA.

(*a*) Cincindela Sexpunctata.
(*b*) Dermestes vulpinus.
(*c*) Epilachna 28-punctata.
(*d*) Cryptorhynchus mangifera.
(*e*) Melolonthini.
(*f*) Hispa ænescens.
(*g*) Aulacophora abdominalis.
(*h*) Opatrum depressum.
(*i*) Chætocmis basalis.

is the Apogonia Blanchardi and the brown one Schizonycha fuscescens (Fig. 66 *e*). The larvæ live for about 4 years in the ground, during the whole of which time it is engaged in living on the fine roots of plants. Where there are large tracts of uncultivated land the grubs can thrive unmolested and the beetles can destroy cultivated crops in the neighbourhood. But though cockchafers do a great amount of damage in Russia and Southern Europe to agricultural

crops, we, in Lower Bengal, have so far noticed them only as a very destructive garden pest, defoliating every rose-bush and other plants in the hot weather. By proper cultivation, the pest can be kept off from plantations, but if they come from uncultivated tracts in the neighbourhood of a plantation, it is very difficult to deal with them. Cockchafer larvæ have been reported from Chittagong as destroying paddy and maize crops, and it cannot be said that there is no danger from this source in localities where uncultivated tracts abound. The fungus (Botrytis tenella) which causes one of the diseases of silkworms known as muscardine, or *chuna-kete*, is said to be destructive to the larvæ of Melolonthini also. Silkworms affected with this disease may be dried in the shade, powdered and the powder may be applied to roots and leaves of rose and other bushes attacked by cockchafers.

1,200. Of the larvæ of *beetles which destroy crops proper*, very few have been noticed, besides the Chrysolmelid beetles, Hispa ænescens (Fig. 66 *f*) and Aulacophora abdominalis (Fig. 66 *g*) which will be separately dealt with in the next chapter. A large sized Cantharidæ beetle (*kánch-poká*), Mylabris pustulata, is destructive to groundnut and *arahar*. A Chrysomelid beetle (Haltica nigrofusca) is said to attack the leaves of garden vegetables in the Himalayas. It has been also noticed defoliating indigo plants in Rangpore. Besides Hispa ænescens there is Chætocnemis basalis (Fig. 66 *i*), another of the Chrysomelidæ, which is said to destroy paddy seedling. A little flat beetle (Opatrum depressum) belonging to the family Tenebrionidæ attacks linseed and wheat plants (Fig. 66 *h*).

1,201. *Lepidoptera*.—These include butterflies and moths. The four wings are covered with imbricated scales. The maxillæ are developed to an extraordinary degree forming a long coiled proboscis or tube with which the insect sucks up honey from plants. The larvæ as well as imagoes are usually brilliantly coloured. The larvæ eat up a great quantity of

green vegetable matter. The distinction between butterflies and moths is not scientific. By moths is understood night-butterflies, and no structural distinction can be established. The classification of butterflies into *true butterflies*, or papilio, *hawkmoths*, or sphina, and *moths* or phalœna, is more generally accepted.

1,202. True butterflies have their antennæ terminating in a club, and they generally fly about in day time. Of these the following may be mentioned as of agricultural interest :— (1) Virachola isocrates, a graceful purplish butterfly, the larvæ of which bore into the fruits of guava, pomegranate, loquat &c. (2) Mancipium nepalensis, or M. rapæ (Fig. 67 *a*), a white butterfly, the larvæ of which have been known to attack gram, linseed, and sugar-cane. This may be looked upon as an Indian form of the destructive English butterfly, Pieris, or Mancipium brassicæ. (3) Papilio erithonius, a large swallow-tailed butterfly the caterpillars of which defoliate orange and lemon trees, in different parts of India.

1,203. The hawk-moths are distinguished by their stout bodies, by their abdomens extending beyond the hind wings and by their narrow wings. None of them are of much agricultural interest, though the big larvæ, distinguished by a horn near the tail, consume a great quantity of leaves.

1,204. Most of the lepidoptera of agricultural interest belong to the third group, *viz.*, moths. The following may be mentioned as of special interest :—(1) The Spilosoma (*suán poká* or *bhuá*) defoliate jute, sunn-hemp, sesamum, castor-oil and other crops. Other hair-covered caterpillars like the Spilosoma have been known to defoliate mango trees, tea, coffee, paddy, *rabi* crops generally and rape in particular. The Alope ricini (Fig. 67*b*) may be mentioned as a common Indian defoliating caterpillar. (2) The Noctues, which are thick-bodied moths with thread-like antennæ, are very destructive in the larval stage. The larvæ are smooth caterpillars with four pairs of pro-legs and one pair of anal claspers, and they

usually do their work of destruction at night, living in daytime hidden in the earth. The following Noctues moths are of special agricultural interest :—(*a*) Achæa melicerte, a greyish moth, with dark-brown hind-wings, marked with greyish white streaks The caterpillars defoliate brinjals, paddy, sugar-cane, cajanus indicus, castor-oil plant &c. (*b*) Heliothes armigera (called variously *leda-poká*, *kajrá*, *lurka*), is a small greyish moth, with dusky-brown hind-wings (Fig. 67 *c*). The caterpillars are known to be destructive to paddy, hemp (cannabis sativa), poppy, *khesari*, Dolichos lablab and other pulses, and *rabi* crops generally, and to immature bolls of cotton. (*c*) Leucania extrania and other Leucanidæ, the caterpillars of which are destructive to young paddy plants, oats and peas. Leucania loreyi (Fig. 67 *e*) has been found very destructive to paddy plants. (*d*) Laphygma exigua (Fig. 67 *f*) attacks lentil plants. (*e*) Agrotis suffusa (Fig. 67 *d*) and (*f*) Ochropleura flammatra both attack opium plants in the same way. (3) Geometres or loopers are long, slender, smooth caterpillars which hump up the middle of the body into a loop in progressing. Their moths are slender-built creatures with large wings and comb-like antennæ. Some of these are known to be destructive to tea and coffee bushes. (4) Dragana pansalis a small moth which is injurious to sugar-cane. (5) Chilo simplex. (6) Paraponyx oryzalis, the caterpillars of which are aquatic in their habits and attack paddy plants. (7) The *Majra-poká* (Chilo Oryzæellus) which tunnel into the green stalks of paddy and wheat. (8) Sphenarches caffer, a minute plume moth the caterpillars of which tunnel into the pods of *popat* bean (Dolichos lablab) in Nagpur. (9) Depressaria gossypiella, the caterpillar of a minute moth which tunnels into cotton bolls. (10) Gelechia cerealella, the caterpillar of a minute moth which is destructive to stored maize. (11) Tinea pellionella,—the caterpillar of this moth is a minute creature that protects itself in a case. It is very

destructive to woollen materials. Other Tineid caterpillars attack paddy, spinning the grains together into a web. (12) Pyralis moths may be also mentioned as injurious to stored

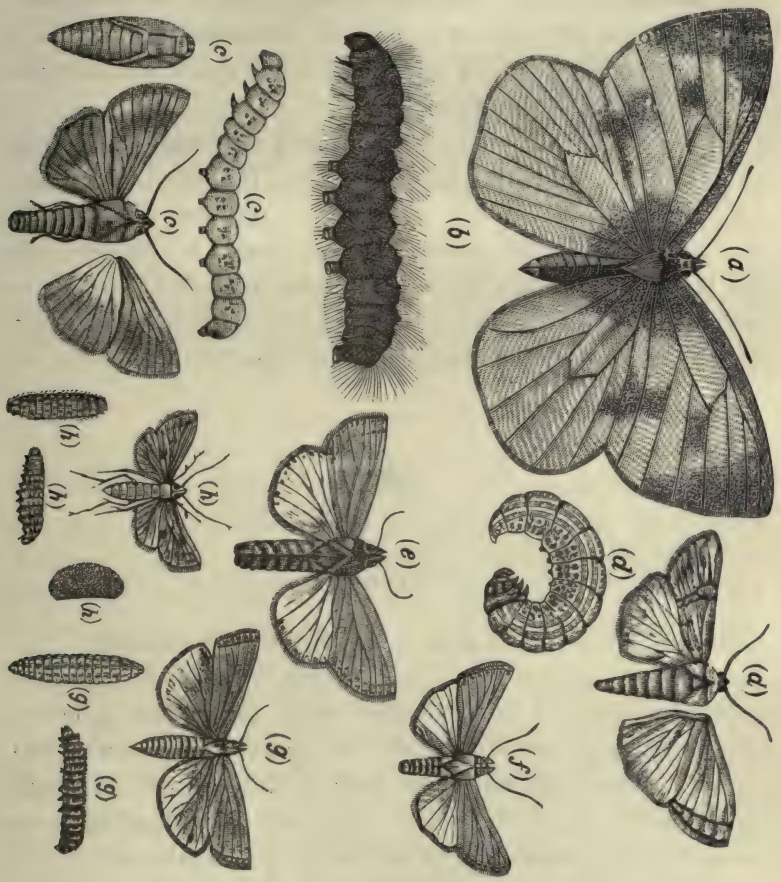


FIG. 67.—LEPIDOPTERA.

(*a*) Mancipium Nepalensis.
(*b*) Alope ricini.
(*c*) Heliothes armigera (larva, pupa and imago).
(*d*) Agrotis suffusa (larva and imago)
(*e*) Leucania loreyi.
(*f*) Laphygma exigua.
(*g*) Chilo simplex (larva, pupa and imago).
(*h*) Lencinodes orbonalis. (larvæ, pupæ and imago).

meal (hence called meal-worms), also to leaves and flowers of mustard. These minute moths have long wings which are not folded up in repose. The antennæ and legs are long and slender, abdomen long and pointed, extending considerably beyond the hind-wings. The commonest example is the Lencinodes orbonalis (Fig. 67 *h*) which spoils brinjal fruits by tunnelling holes in them.

1,205. *Diptera.*—These have only two wings with few veins, not clothed with scales or hair. The hind-wings are replaced by rudimentary *halteres* or poisers. The mouth is furnished with a proboscis. The female is stingless, but the last joint is often prolonged, into a beak-like process which helps it in making holes for the deposition of eggs. The larvæ are footless maggots ; pupæ inactive. Nearly all



FIG. 68.—DIPTERA (MOSQUITO).

dipterous larvæ live in fluid or in semifluid substances (*e. g.* putrid meat) and even the imagoes (*e.g.* ordinary house flies) have the power of living under water for an hour or more. The spiricles are situated close to the anus or posterior extremity of the body and they push up this end of the body occasionally to get fresh air. The slender wriggling larvæ we see in dirty water are larvæ chiefly of mosquitoes.

1,206. The principal families of dipterous insects are : (1) Pulicidæ or fleas (*pishu*) ; (2) Muscidæ or flesh and house flies ; (3) Œstridæ or botflies ; (4) Hippoboscidæ or sheep ticks ; (5) Tabanidæ or horse flies ; (6) Culisidæ or mosquitoes ; (7) Chironomidæ or gnats ; (8) Cecidomyiidæ or gall-midges ; (9) Tipulidæ or crane-flies also called Dadilonlegs ; (10) Syrphidæ or aphis-eaters.

1,207. Of the muscidæ insects may be mentioned: (1) Dacus ferruginous, the grubs of which are found in ripe mangoes, and (2) Carpomyia parctalina which is very destructive to gourds, melons, cucumbers, &c.

1,208. Of Cecidomyiidæ may be mentioned Cecidomyia oryzæ, a minute fly which attacks paddy, chiefly *aus* paddy.

1,209. Bot-flies do a great deal of damage to ox-hides. They live in the larval state either in stomachs of animals, or in tumours under their skin, or in their nose and frontal sinuses. The class of bot-flies called Hypoderma or Warbles, spoil hides of oxen. Tanners can doctor up the holes made by the botflies, but hides with such minute holes are classed as second class hides. Rubbing of kerosine, when cattle are troubled with these flies, is the best treatment.

1,210. Fleas (*pishu*) which are parasitic on domestic fowls, dogs, cats, &c., pass their larval stage in dust, and they must be looked upon as a sign of general uncleanness of the house and the animals affected. The pulicidæ or fleas are without wings. Their bite produces blister in man, but they do not thrive on human skin. The best prevention of fleas for domestic fowls is the dust bath. If the dust consists partly of ashes and lime fleas get little chance.

1,211. We may just mention here the Tachinid parasites, Trycolyga bombycis and Masicera grandis which 'blow' the silkworm and the tusser silkworm respectively.

1,212. *Hemiptera* (*Rhynchota*).—These are devided into two groups, the H. Heteroptera and the H. Homoptera. (1) The Hemiptera Heteroptera have their fore-wings horny and the hind-wings (as also the tips of the fore-wings, as a rule), membranous; usually provided with a scutellum or shield-like protection; antennæ long, 4 or 5 jointed; head generally free. This group includes the capsidæ or plant-bugs and the membranacei or parasitic bugs (*e.g.*, Cimex lectularius, the ordinary bed and chair bug, or *chhar-poká*). (2) The Hemiptera Homoptera have their head soldered to

the thorax ; short antennæ ; wings, sometimes one pair and sometimes both pairs, absent ; and when present they are membranous. This group includes the True Lice (*e.g.*, the hair lice, Pediculus capitis, or *ukun*), the Aphides or plant-lice and the Coccidæ insects (bark-lice or scale insects), both of which are known by the generic name of blights or blight-insects. They also include Cicads and Membracidæ. Two species of Membracidæ we commonly see at the Sibpur Farm in October and November on our *arahar*, cotton and Hibiscus cannabinus plants, ants keeping watch over them and feeding on the honey they secrete. The larger of the two membracidæ which we have at Sibpur is the Oxyrachis tarandas, the honey of which is made use of by a big black ant (Camponotus screceus), and the smaller one is the Loptocentrus reponens, the honey of which is made use of by a small black ant (Dolichoderidæ).



FIG. 69.--HEMIPTERA HETEROPTERA (BUGS).

(*a*) Leptocorisa acuta. (*b*) Lohita grandis.

1,213. Of the heteropterous insects may be mentioned (1) Apinis concinna, a pentatomidæ bug which attacks *rabi*

crops and vegetables. It has a prominent beak ; oval body ; large meso-thorax ; the scutellum or shield very large, covering nearly the whole of the wings and abdomen. (2) Leptocorisa acuta (Fig. 69 *a*), the rice-sapper (*Gandhi or Bhoma*) has a small triangular scutellum ; long and slender body,—yellowish brown in colour. (3) Dysdercus cingulatus, which has a very short scutellum, is a conspicuous red-coloured insect, about the size of a wasp. It attacks cotton, bottle-gourds, musk-mallow, cabbages &c. (4) Oxycarenus lugubris which is very like the clinch-bug of America (Blissus leucopterus), is a small, black, fly-like insect with a short scutellum, which commonly attacks cotton plants and cotton bolls. (5) Lohita grandis (Fig. 69 *b*) which attacks cotton plants, (known as *kapasi-poká* in Nuddea), is also a slender insect with hard wings and short scutellum. (6) Another bug (Physopelta schlaubuschii), known as *kuti poká* in Nuddea attacks rice plants. (7) The so called 'mosquito blight' (Helopeltis theivora) of tea, is also a bug. (8) The Blissus gibbus is a bug which spoils the sugar-cane leaf and growing canes by feeding on the sap or juice.

1,214. Of homopterous insects may be mentioned the following :—(1) Aphis brassicæ, the *jáb poká* of mustard &c. and other aphides. Aphides secrete a sweet honey-like substance for which they are much sought after by other insects. This is a wise provision of nature to keep them down. The fully sexual forms have large wings but they are mainly propagated a-sexually. Some live on leaves, others suck the juice of green stems and leaves, others again live on roots. They are green or brown, or black, in colour. Phylloxera vastatrix is the vine aphis which attacks both roots and leaves and produces little galls also. The tea-aphis (Ceylonia theæcola) is a blackish insect which sucks up the juice of young tea leaves and causes their edges to curl up (Fig. 70 *a*.) (2) The Psyllidæ the larvæ of which are covered by a cottony secretion, are small leaping bugs. Like aphides they subsist

on the sap of plants, and exude a sweet secretion. Some species produce galls. Psylla isitis which is extensively destructive to indigo in Bengal, is a gall-forming Psyllid. The Psylla cistellata is a small black fly-like insect which attacks young shoots of mango and makes them abortive. (3) The Cicads are unable to leap, and they are larger than aphides or psyllids and sometimes very large. The males are provided with conspicuous drum-like appendages to their abdomen. They are black, green, or yellowish in colour and the wings are either transparent or marked with a row of moderate sized black spots on the nervures. The larvæ and pupæ resemble the imago in general appearance except that the wings are undeveloped. Some large-sized cicads keep up a perpetual chirping in the silence of forests. Although cicads are commonly to be seen feeding on the saps of plants none of them have been described as injurious to crops. (4) Membracidæ, which we have already spoken something of in p. 696. (5) The Coccidæ or scale-insects are often very injurious to cultivated plants and specially to trees and perennials. The males have two wings. The females are wingless and scale-like in appearance. Eriochiton cajani attacks the *arahar*. Aspidiotus destructor is destructive to cocoanut

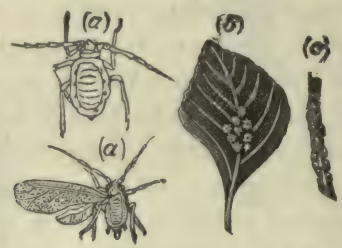


FIG. 70.—APHIDES AND SCALE-INSECTS.

(*a*) Ceylonia theæcola (female and male).
(*b*) Icerya Ægyptiacum. (*c*) Aspidiotus flavescens.

palms. Chionaspis aspidistræ is injurious to the areca nut palm. Dactylopius Bromelii, causes the curling disease of

mulberry bushes, locally known in the silk-districts of Bengal as *Tukrá*. Icerya Ægyptiacum (Fig. 70 *b*) caused wholesale destruction of trees in Egypt some years ago, and this insect has been seen on different trees in Calcutta and in Madras. Aspidiotus flavescens (Fig. 70 *c*) attacks tea-bushes one or two years old and often ruins them entirely.

1,215. *Orthoptera.*—These have four wings, the anterior ones being narrower than the posterior ones which are usually folded up, and they are leathery rather than horny in their texture. The larvæ and pupæ are both active. Eggs generally enclosed in a case. The hind legs are usually fashioned for leaping. (1) The commonest example of this order will be found in the Periplaneta orientalis, the ordinary cockroach, belonging to the family Blattidæ. (2) To the family Phasmidæ belong the stick-insects and leaf-insects, with long slender bodies and legs, some of which are wingless. Some insects of this family are very destructive to cocoanut trees in the South sea Islands, and when alarmed they squirt out a highly acrid fluid which causes blindness if it reaches the eyes. (3) Mantidæ are not agricultural pests. They devour insects and are helpful to agriculture. They also have slender stick-like bodies. They deposit their eggs in spongy ball-shaped nests. (4) Next come the acrididæ (short horned grasshoppers) to which belong the following Indian varieties of migratory and invading locusts :—Acridium peregrinum, Acridium succintum, Acridium melanocorne, Acridium æruginosum, Caloptenus erubescens, C. caliginosus, Cyrtacanthacris ranacea, Oxyá furcifera, Pachytylus cinerescens. To the acrididæ belong also non-migratory locusts and grasshoppers of which many are destructive to crops. Crotogonus sp., a small thick-set, brown grasshopper, is destructive to young crops of all kinds as soon as they appear above ground, such as, indigo, *kalai*, *barbati*, opium, wheat, barley, linseed, rape-seed, *til*, *bájrá*, &c. Catantops axillaris (*Kat-pharing*), and Euprepocnemis bramina attack young paddy plants. Œdalus

marmoratus and pæcilocera hieroglyphica defoliate sugarcane. The most destructive of all the grasshoppers is the Hieroglyphus furcifer which attacks paddy and maize plants. (4) Then come the *Gryllidæ*, or the crickets (*Ui-chingri*, *usrang, jhingun*), the abdomens of which are furnished with long ovipositors. An enormous mole-cricket (Schizodactylus monstruosus) is injurious to young tobacco and other crops growing on high land in Behar, where it is known as Bherwa. Gryllotalpa sp. is a cricket which is said to injure opium plants by cutting them off when they are considerably advanced in growth. Acheta sp. is said to injure young opium. Liogryllus bimaculatus (Fig. 71) spoils young potato, cabbage



FIG. 71.—LIOGRYLLUS BIMACULATUS.

and other *rabi* crops. (5) The long horned grasshoppers (locutidæ, which, however, do not include the common locusts and grasshoppers) are somewhat rare.

1,216. *Neuroptera.*—All the four wings are of similar texture and with numerous veins. The wings are sometimes hairy. The Dragon flies (*jhinji poká*, or *jhinji-pharing*) are the commonest example of this order. They can be seen in Lower Bengal in the month of October specially in large numbers chasing their insect prey wherever they fly and they are to be looked upon as one of the best friends the farmer has. Their larvæ live in water, and the larvæ of the few species that do live on plants feed on aphides &c. The white-ant is the other commonest example of this order, but they are exactly of the opposite character to draggon-flies and for the study of this a separate Chapter will be provided.

1,217. *Thysanoptera*.—Only the Thrips belong to this order. The wings are long, narrow, straight, equal and veinless. These minute insects either fly or hop very vigorously. Many flowers are attacked by thrips which with their biting mouth keep chewing the delicate leaves and pollen grains. The female is apterous *i. e.*, without wings. The males are scarce, and propagation probably takes place by parthenogenesis. The males are different in appearance altogether from females. A minute black winged thrips has been noticed spoiling the turmeric crop in Madras. Another thrips has been reported as injuring the poppy in Behar where the insect is called *lhi* or *lehi*.

1,218. *Thysauneura*.—Wingless, mandibulate insects, with long, many-jointed antennæ, abdomen composed of ten segments, and not undergoing metamorphosis. Not being parasitic on plants they have no interest for students of agriculture, though they are most curious animals. They are covered with scales or hair. They have two or three long caudal appendages. The "Silver-fish" or "Fish-insects" (Lepisma) which are so destructive to books, are the commonest example of this order.

1,219. In the succeeding Chapters we will give more detailed description of the commonest agricultural pests and treat each subject from the farmer's point of view.

CHAPTER CXIV.

LOCUST (ACRIDIUM PEREGRINUM, A. SUCCINTUM, &c.)

THERE are two important breeds of Indian locusts, the Rajputana (A. peregrinum) and the Deccan (A. succintum) breeds. The Rajputana locust usually breeds twice in the year, while the Deccan locust only once. The breeding

ground of the Rajputana locust are the sand-hills of Raj putana, Sind, the Punjab, Jeypore and Ajmere. The chief home of the Deccan locust are the Western Ghauts. They are also found to breed in Konkan and the adjoining parts of the Deccan. From these two centres both varieties of locusts migrate to all parts of India and sometimes they come to Bengal also. The A. Succintum prefers the invasion of moister tracts, while the A. Peregrinum chooses harsher climates. Besides these two migratory locusts there are others, and there are also some varieties of stationery locusts in Bengal and other provinces of India. These also do some little amount of damage.

1,221. The female lays eggs in sand after making a hole in the sand about an inch deep with the hinder part of the abdomen. After she has laid the eggs she pours some frothy liquid on the top of the hole, which serves both to adhere the eggs together and also to make a covering for the hole. This takes place in March in the Punjab, and in June in Rajputana, *i.e.*, after the first early showers of rain. Eggs are laid in some tracts later on in the rainy season. Each lump, if it is dug out of the ground, will be found to consist of 50 to 100 eggs. They remain for about 3 weeks in the ground after which little green insects creep out of them. In a few hours the green integument is thrown off and each insect now appears as a little black wingless grasshopper. It hops about, lives on green plants, increases in size, moults several times, gradually develops four wings, and in about a month becomes a full grown locust, ready to fly in shoals of millions over whole provinces, alighting now and then to eat up fields of growing crops, very often resting at night on trees and shrubs and then with sun-rise starting off again and passing over new tracts, alighting again as before as they feel hungry. Not finding any suitable ground for laying eggs they generally die off, but in the sandy deserts of Sind, the Punjab and Rajputana, they alight and lay eggs undisturbed in the sand at

the end of the rains giving birth to new swarms to trouble the cultivator once more.

1,222. The easiest way of dealing with the insect, is to dig up and destroy the eggs, if information can be procured where they have alighted and laid eggs. In the district of Rawalpindi 500 maunds of eggs were thus dug out one year and destroyed. It is not enough to bury them or to plough them in, but actually to break and smash them. It is not so very difficult to destroy large quantities of the larvæ either, when they march along hopping. They never turn to the right or the left but blindly march along. If trenches can be dug along their path they tumble into them and then they can be destroyed in shoals in these trenches. The trenches need not be more than a foot deep, and the insects can be encouraged by children marching behind them with brushes of straw, to march along at a quicker pace to their destruction. Another plan is to place lines of burning straw &c. along their path and they will be found to march into the fire also quite blindly and get burnt. While they are on their hopping march they can be also beaten and trodden to death in large numbers. But when they have once got wings the inhabitants of a whole village should come out as soon as they notice a flight, and prevent the insects alighting by frightening them with sticks and by yelling and crying and beating of drums and tin cans. At night, if fires are lighted the locusts are found to fly into the fire like moths, and get burnt. The larvæ of Deccan locusts do not march into trenches and it is therefore more difficult to deal with them.

1,223. The following remedy was recommended in an article which appeared in the *Englishman* newspaper: "Take one pound of arsenic and one pound of caustic soda. Take four gallons of water, bring to boiling point and then add the caustic soda ; when dissolved, add the arsenic, stir well and boil for a few minutes, care being taken not to in-

hale the fumes. Take as required half a gallon of this mixture, and add four gallons of hot or cold water and ten pounds of brown sugar. Dip grass, stalks, or twigs in this liquor and place them along the road in the fields, or anywhere about grass or low growing crops, or splash on the liquor to anything which the locusts may be observed to have a special taste for. Locusts will come from a hundred yards or more attracted by the smell of the sugar. They eat and die and are eaten by other locusts. If they take the poison freely, they will be seen covering the ground with their dead bodies. Some recommend a stronger solution but the one given is the safest to use. There is no fear of cattle being poisoned as the small amount of poison on the grass, stalks or twigs, is not sufficient to injure them. Fowls have fed on arsenic which has destroyed locusts, without hurt. The medicine should be kept ready for use and put down immediately there are any indications of a coming flight of locusts. Ground locusts or 'hoppers' are much more easily got rid of, and their ravages can be put a stop to at once; it is the 'flyers' that give the trouble, as they appear suddenly, feed, and are sometimes gone before the poison can be put down."

1,224. The following paragraph appeared in an up-country newspaper (the Hindosthan):—

1,225. "We hear that the fungus discovered in 1896 by Dr. Eddington in the dark lands of Southern Africa, which was kept growing at the laboratory and experimented upon, has been now declared by some of the Bacteriologists, to be a most effective and deadly poison for destroying locusts. It is reported that wherever it has been introduced it has given satisfactory results. It is very easily carried from one place to another in a test-tube. Though it is deadly poisonous to locusts yet strange to say it is quite harmless to cattle or to any other form of animal life. This, according to the Bacteriologists, is owing to its belonging to the class of *moulds* and not to the *bacteria*. The methods of its prepara-

tion and application are described as follows :—'The contents of a tube are taken out, to which is added a small quantity of sugar, and the whole well mixed together. This is dissolved in about a quart of water, which has previously been boiled and allowed to cool. A few pieces of cork, steeped in boiling water and cooled, are floated in the mixture. The water covered with a piece of paper and allowed to stand during the day in a warm corner until fungus is seen to be growing around the pieces of cork. The preparation being now ready, some locusts are caught, dipped into the fungus and allowed to rejoin the swarm ; or some of the swarm are confined in a box which contains a favourite food moistened with the fungus, allowed to consume it and then to return to the others. Another and apparently more deadly way of using the fungus is to spread it over the affected parts where the locusts alight to feed, the damper the ground the better.' Dr. Eddington is said to have destroyed 95 per cent. of locusts in one year by this process in Buluwayo. We hope that this fungus will find its way out to India, to free her lands, especially the fields and orchards of the locust pests, which are so common here."

1,226. The Agriculture Department of the N. W. P. and Oudh have got this fungus out for experiment, but with what result is not yet known.

1,227. It may be mentioned here that Mahomedans catch locusts for food and even preserve them for this purpose as they regard it in the light of a holy food from Mecca. Dessicated locusts may be tinned and exported to Europe where they are prized as food for insectivorous cage birds and game birds.

CHAPTER CXV.

GRASSHOPPERS AND CRICKETS.

THE paddy grasshoppers (Hieroglyphus Furcifer).—This acrid insect (*Pharing*) does very extensive damage to the paddy crop also to young maize and *Juar*. It attains full size when the paddy crop is nearly ripe for cutting and when cracks in paddy fields are numerous. The females can be seen laying eggs in the cracks in lumps of 40 or 50 about the end of November or beginning of December ; 5 or 6 of such lumps being deposited in different crevices by a single female. Throughout the dry season nothing more is noticed of the pest, and hidden in the crevices a certain proportion of the eggs hatch at the beginning of the rainy season. Where cold weather cultivation is practised, or where very heavy showers of rain occur in April or May keeping paddy fields submerged under water for some days before the hatching of the eggs commences, very few get the chance of hatching. When the grasshoppers are small in July and August they hop about in the water of the paddy fields and live on the young paddy plants, hardly noticed by cultivators. They begin to be noticed in September, but it is only when the plants are in ear in October and November, that the cultivators begin to recognise that the grasshoppers are doing mischief. They are non-migratory. In one instance the author noticed whole fields of paddy on one side of a road in the district of Midnapore, ruined by this grasshopper, while on the other side of the road scarcely any damage could be noticed, and while on one side myriads of grasshoppers were hopping about and flying, on the other side there were only stray ones.

1,229. Besides locusts and Hieroglyphus furcifer, there are several other grasshoppers and crickets which are injurious to

crops. Often several species of grasshoppers attack a crop all at once. The main difference between a cricket (gryllidæ) and a grasshopper is,—the cricket is furnished with a long ovipositor, while the grasshopper has only a rudimentary ovipositor. A cricket which spoils indigo plants by biting through the roots, is locally called *Bherwa* in Bihar. It has been identified as Schizodactylus monstruosus. There are other crickets injurious to potato crops, to young *juar* plants, to tea bushes, to cotton, cabbage and other seedlings. In 1893 serious damage to jute and rice crops was reported from Comilla as caused by a criket, which was identified in the Indian Museum as Brachytrypes achatinus.

1,230. The only suggestion that can be offered regarding remedial measures when crickets and grasshoppers are found very destructive to an ordinary agricultural crop, is—"Try Hopperdozers." They are likely to prove efficacious, as they have proved efficacious in similar cases in America. A Hopperdozer is a long and shallow trough mounted on wheels, and containing water and kerosine oil, or a quantity of tar only, and dragged or driven along, an infested field. The grasshoppers jump up and get drowned of themselves in the kerosine and water, or get entangled and killed in the tar. The least touch of kerosine oil kills insects. To avoid spilling, the trough should have partitions of tin. The trough itself may be made of tin, say, 9 ft. long, 1 ft. wide, 2 inches deep in front end 1 ft. behind. This trough may be mounted on a wooden frame having two wheels at the two ends. Two men may drag it along with ropes attached to the two ends of the wooden frame. A canvas screen or apron may be added to the hinder part of the trough, which will further help in bringing the grasshoppers into the trough or kill them by contact with the kerosine with which the canvas is saturated.

CHAPTER CXVI.

GRANARY PESTS.

THE grain weevil (Calandra or Sitophilus Oryzæ).—This insect does a good deal of damage to stored rice, wheat, barley, maize, *juar,* &c., 3 to 4 seers per maund being eaten up by the weevil, in course of a year.

1,232. Each female lays about 150 eggs, generally one egg being laid on one grain of cereal. She cuts a minute crevice on the grain, lays the egg in it, covers up the crevice with dust &c., and then goes on to lay other eggs. Throughout the cold weather and hot weather this goes on, the weevils having come out during the preceding rainy season from grains stored in the same godown or vessel and remaining hidden all this time in cracks and crannies of the godown or the vessel. The egg is almost too minute to see with the naked eye. It hatches and the grub hatching out goes on burrowing inside the grain and eating into its substance, leaving a minute aperture behind it, to enable it to breathe. In a few weeks the grub changes into a pupa, and for a while remains dormant until it becomes a full formed weevil when it bites its way out of the grain. The breeding goes on all the year round and only quicker in the rains when the grains are softer and readily eaten through by the grubs. Every egg laid before the rainy season commences, gets the chance of becoming a weevil; so although we may find a few weevils in the cold and the hot weather, we find the godown swarming with them towards the end of the rainy season. The time taken for the egg to develop into the perfect insect is about two months, though the time required for development depends on the temperature.

1,233. The godown or the vat where the grain is

stored must be thoroughly cleaned, white-washed or tarred in the dry season, and then the grain stored and kept well covered up. The surroundings of the godown should be also clean, for the weevils crawl out of old stray and rejected grain and attack the new grain stored in the godown. The grain should be spread out very thin in the hot sun, if weevils are subsequently noticed in it; but under ordinary circumstances weevils can be only kept down by cleanliness and care, but not altogether prevented. In *jálás* tarred inside and out and kept hermetically sealed up in the dry season after storing the grain, there is almost no fear of loss from weevils. But Carbon bisulphide gives the most absolute protection. In shops and godowns where such arrangements are not feasible, a mixture of lime and crude carbonate of lead (*Sapheda*) is used, but the use of this mixture should be deprecated.

1,234. Paddy is seldom attacked by this weevil and hard wheats are not so subject to its attack as soft wheats. The weevils are not able to penetrate a thick layer of chopped straw or of dry *neem* leaves. Hence, bags of grain stored in open vats first cleaned and tarred inside, and covered up simply with chopped straw or dry *neem* leaves, are found nearly entirely free from weevils.

1,235. Miss Ormerod recommends "the plan of trapping by setting vessels of water" which attract the beetles in great numbers from the grain.

1,236. At Demarara they attract ants into rice godowns with sugar, and then the ants attack the weevils.

1,237. The plan adopted in this country for protecting cobs of maize kept for seed, is to hang them up in bunches at the end of Bamboos and keep them exposed to light and air and smoke inside ordinary dwelling houses. Indeed the weevils are more destructive in town godowns than in villages, where sweeping and *leping* are practised daily, making quiet inroads of pests somewhat more difficult.

1,238. The weevils themselves are attacked in the granaries by certain Hymenopterous parasites belonging to the order chalcididæ. Three such insects destroying the weevils, have been noticed.

1,239. The vernacular names of the granary weevil are *chèlè poká* and *henà poká*.

1,240. *The Grain moth* (Tinea granella).—Another granary pest which may be seen in old stores of rice, and somewhat resembling the tiny moth spoiling clothes and furniture, is the wolf moth (Tinea granella). The larvæ of this moth collect grains of rice around them into lumps and eat them through into shells. In the chrysalis stage the insect remains hidden in cracks and crannies of the godown. The remedies applicable are similar to those recommended in the case of the weevil.

1,241. A minute grain moth attacks stored rice, maize and wheat alike. It has been identified as Gelechia cerealella.

1,242. *Other granary pests*.—Stored grain is particularly subject to the attack of a brown weevil (Bruchus chinensis) called in Bengali *ghora-poká*. Pea is subject to the attack of another Bruchus weevil, which is larger than the grain weevil.

CHAPTER CXVII.

PADDY PESTS.

THE Rice-bug (Leptocorisa acuta).—This insect belonging to the order Rhynchota and section Heteroptera, is known to be very destructive to the paddy crop all over India while the crop is still green. It is greenish brown in colbur, and nearly an inch in length with slender body, long

legs and jointed antennæ, and of very offensive smell, from which it derives the name *Gándhi.* It settles on the rice plants in large numbers and sucks up the juice when the ear-heads are just coming up. It often destroys half the crop of a whole locality or district. The mode of parasitism has not been studied; but it seems the winged insects only lay eggs on stems, while it is the larvæ hatching out of the eggs which actually burrow into the stems of the plants and do the work of destruction. The pupæ probably hybernate in the soil, and when owing to early approach of the rainy season, a long preparation of land is not possible, the majority of these pupæ get the chance of transformation into images and continue breeding, as soon as rice plants are up on which the oviposition is effected. In any case, there is hardly a rice field where a few leptocorisa acuta may not be observed if search is made for the insect, and if for two or three seasons they get a chance of rapid multiplication due to imperfect cultivation and short exposure of turned up soil to the attack of birds, ants, &c.

1,244. The remedy obviously suggested is a preventive one, *i. e.*, ploughing up of rice fields, in the cold weather and stirring up their soil from time to time till the sowing season. If the soil is too hard immediately after the rice harvest, the first shower of rain after the harvest should be taken advantage of in ploughing up the stubble.

1,245. A caterpillar that does not do much harm may be incidentally mentioned here. It is the paddy stalk borer (Chilo sp.).

1,246. *The Rice Hispa* (*Hispa ænescens*).—We had at the Sibpur Experimental Farm swarms of this black beetle in the rice transplanting season of 1899, *i. e.*, at the same time when several districts reported damage from this pest. It belongs to the family Chrysomelidæ, of the order Coleoptera. It does damage both in the larval and imago stages, and it pupates on the young

leaves. The insects feeding on the green cellula portions of leaves, the white fibrous blades remain exposed which give a withered appearance to whole fields. But the plants being quite young at the time, they recover their vitality and the injury done is not so great as it appears at first. The full development of the beetles from eggs takes place within a fortnight to three weeks. But a second generation is not known to succeed during the same season, and it is not known how the beetles appear in such swarms and disappear. Probably the large swarm which appears at the time of transplanting is the second generation from stray hispas which have not been noticed and which feed on the seedlings and breed again on the plants after they are transplanted. But a still larger third swarm not being known, it is doubtful if the theory just stated is correct. Closer observation can alone determine this point. Their sudden appearance and disappearance are at present looked upon in the light of a mystery. Several remedies were tried at Sibpur. Dusting of ashes mixed with lime and arsenic, of soot, of turmeric powder, bellowing Carbon-bisulphide and Cyanide of Potassium vapour, spraying tobacco decoction, kerosine emulsion and a solution of asafœtida and aloes, were tried in different plots with no marked effect at the time of application. But the beetles disappeared the next day. Another swarm however appeared in a few days and they were similarly treated. At this second attack were noticed large numbers of tiger beetles (Cincindela sexpunctata) feeding on the hispa and probably they were of greater help than the insecticidal applications. The *prevention* of the pest was successfully carried out at the same time by dipping each bunch of seedlings immediately before transplanting in a solution of asafœtida. Probably the stink kept the insects off, though some of the plots already attacked were also treated with asafœtida solution with no immediate result. Smoking with Sulphur and Chlorine fumes has been also recommended.

1,247. In the vernacular the hispa is variously known as *Morchè poká, Sukho poká, Senko poká, Pámari poká, Paruli poká.*

1,248. A chrysomelid beetle (Phœdon brassicæ) is known to attack the mustard crop, and another (Leptispa pygmæa) to attack young sugar-cane plants.

1,249. *The Rice Midge* (*Cecidomyia oryzæ*).—Serious injury to the paddy crop done by this dipterous pest, was first reported in October 1880 by the Magistrate of Monghyr and since then it has been recognised as a pretty common and very destructive pest of the *aus* paddy crop, specially in Bihar districts, where it is known as *mechhia*. The Hessian fly of Europe and America (Cecidomyia destructor) which feeds upon the sap of green stalks of wheat, and the wheat midge (Cecidomyia tritici) which renders wheat plants abortive by devouring the pollen grains, are two allied species. The rice-midge is known to devour pollen grains in the same way as the wheat-midge. The maggots which are probably deposited on the ears of rice in the living stage are at first semi-transparent, but they get darker with age, and when full-grown, resemble linseed imbedded in the substance of the ear-head. The destruction caused by the wheat-midge and the Hessian fly is so considerable, that it would be wise to guard against the rice-midge.

1,250. *The 'Pattanai' butterfly* (*Suastus gremius.*)—Occasionally green paddy plants are attacked by the larvæ of a butterfly belonging to the family Hesperiidæ and sub-order Rhopalocera of the order Lepidoptera. The butterfly (Fig. 72) from one extremity of the wing to the other when fully expanded, is about $1\frac{3}{4}$ inches and it is of glossy brown colour on the upper side of the wings, with pale yellow spots at the fore-wings. The larvæ when full grown are about an inch in length, cylindrical and tapering at both ends, light green in colour, with a deep green line extending down the middle of the back from one extremity to the other. The



FIG. 72.—SUASTUS GREMIUS (LARVA, IMAGO AND PUPA).

spiricles are black. On a sunny day they remain hidden in shelters of leaves which they construct for themselves with silken threads somewhat in the style of leaf rolling insects. Continuous heavy rains wash them down and they are killed in this way. We noticed only a few of these caterpillars in July 1899 at the Sibpur Farm and though they lived upon the green leaves of paddy plants, they did no appreciable damage. But that they are not able to multiply rapidly and develop occasionally into a destructive pest, is not asserted. It seems to be recognised as a very destructive pest of the rice plant by the cultivators of Balasore, and it is just as well to pick and kill the caterpillars when they are noticed in rice fields, and to depend on the hybernating pupæ being killed by constant and long continued stirring of the soil before sowing, as recommended in the case of the Leptocorisa acuta. The pale yellowish green pupæ are formed in the rolls of leaves made by the caterpillars, but they probably drop down and hybernate in the soil. The butterfly lays eggs singly on the upper side of leaves, early in the season when the rice plants are quite young. The larvæ are known to live not only on paddy leaves but also on tender leaves of the date-palm.

CHAPTER CXVIII.

CUT WORMS (NOCTUIDS).

THE Noctuid larvæ known as *kátree-poká*, *kájrá*, *kumwah*, *ledá-poká*, or *chorá-poká*, remain hidden in the earth in day time and the moths fly only at night, or in the dusk. Some species venture out in day time, cut tender pieces of stems and take them down into their burrows for consumption, or remain hidden in leaves and stems on a bright day. They attack young plants of rice, wheat, poppy, *khesari*, cabbage, turnip, mustard, linseed, tomato, tobacco, cotton, indigo, and potatoes, and perhaps other plants, and they destroy far more seedlings than they can possibly consume. Potato and poppy plants remain subject to the attack of the pest to the last, as their stems are always very tender and the damage done to these crops by cut worms is often very considerable. The pupal stage is passed altogether under ground, and thorough preparation for a long period seems therefore to be the best preventive. From November to February, when the moths are to be commonly seen in the evening, the eggs are laid on leaves in small batches, often two or three layers deep and then lightly covered with the down of the parent moth's abdomen. Probably there is a second generation in the rainy season. The larvæ are more active when they first come out, progressing like geometrite caterpillars, but soon become fat and in appearance somewhat like stumpy silkworms. It is at this stage of its life that the insect is most voracious and wantonly destructive. Each caterpillar has been known to cut down 50 to 100 plants of potatoes and poppy in one night. The pupation goes on in the soil 3 to 8 inches under the surface, and the moth emerges in about a month. Kerosine emulsion syringed under each plant was tried successfully some years ago in the jail garden of Khulna against Agrotis suffusa. At the jail

garden of Berhampore also this insect proved most destructive to the potato crop, until the method of sowing seed of potatoes along with a mixture consisting of rape-cake, ashes, salt, lime and a little white arsenic was resorted to. No loss took place since then from this cause, and the use of this insecticidal manure is recommended as a preventive.

1,252. Besides Agrotis suffusa, there are many other Noctuid moths which are destructive to vegetables, poppy &c. One of these is the Heliothes armigera, called Kujrain in Monghyr and Boll-worm in America. Young bolls of cotton are eaten into by these caterpillars and they also feed on maize, poppy, tomatoes, peas, beans, and *khesari* and other pulses in the cold weather, and also in the rainy season. There are three generations of these insects in the year. The carterpillar feeds on the lower surface of poppy leaves and also on seeds and the seed-pods or opium-capsules it gets entrapped in. A full grown caterpillar is over 1½ inch in length. It pupates in the earth. A single female moth of the Boll-worm is able to lay as many as 500 eggs, layed at dusk, chiefly on cotton plants. The larvæ live chiefly on leaves, but later on they bore into buds and bolls. Sometimes after devouring the contents of one boll, the larva will come out and attack another boll. The holes made by the caterpillars attract the chrysomelid beetle, Aulacophora abdominalis, which continues the destruction of the bolls. It is the third generation from January that is usually found parasitic on the cotton plants in about July and August.

1,253. The common cabbage moth (Mamestra Brassicæ) is also a Noctuid. It is a brown moth with transverse black markings on the fore-wings, the centre of which is marked with white.

1,254. The Achæa melicerte which feeds on the leaves of the castor-oil plant and the *arahar* plant, the Plucia nigrisigma which attacks the gram, the Leucania extranea which attacks the pea, the Leucania loreyi which destroys paddy

plants, are also Noctuids. L. fragelis attacks young wheat and millet plants. Prodenia littoralis caterpillars, also belonging to the Noctuids, did a great deal of damage to mulberry plantations in the district of Murshidabad, a few years ago. It is also known to attack potato and tobacco plants. The jute is also subject to the attack of another Noctuid.

1,255. The Noctuid parasite that does most harm during the hot weather is the Agrotis segetis. It is most destructive to the indigo crop. The moths lay eggs at night on young indigo plants in March or April. In a week the eggs hatch and the larvae keep on eating the leaves for three weeks until they pupate, when they go down deep in the soil. The pupal stage lasts for more than a month, and a second and a more formidable crop of caterpillars sometimes does far more damage in the indigo districts in July, than the first crop in May.

1,256. Spraying is not likely to prove a practical remedy for Noctuids. Long and thorough preparation of the soil, and the use of an insecticidal and manurial mixture along with seed consisting of arsenic, lime, ashes, soot &c., is likely to prove more efficacious. Some tachinid, chalcid and ichneumon flies are parasitic on Noctuid larvæ in the same way as tachinid flies are parasitic on silkworms.* Crows, and starlings are also very fond of ferreting out and devouring the larvæ and pupæ of cut-worms. In cloudy and rainy weather when the caterpillars come to the surface they are more readily devoured by birds. The same is the case after irrigation, and thorough irrigation is a very good remedy against this pest. In poppy fields, hand-picking of the grubs may be practised. Dusting the plants in the evening with a mixture of quicklime and ashes and the method of catching the Noctuid moths in lantern traps and also in basins containing a mixture of molasses and vinegar, have been successfully tried.

* Vide Handbook of Sericulture by the author (p. 112 &c.)

CHAPTER CXIX.

THE SUGAR-CANE BORER (CHILO SIMPLEX).

THE larvæ of this moth bore into the stalks of sugar-cane, maize, *juar* and probably also the *kashia* grass (Saccharum spontaneum). A brinjal stalk borer is also a chilo. The borer attacking the sugar-cane, often results in putrefaction, so that the whole stalk becomes worthless. Often the borer is followed by a fungus in the work of destruction, and the wholesale loss occurring in some districts to soft varieties of sugar-cane, is caused jointly by the borer and the fungus, the latter in fact doing far more harm than the borer in giving rise to an epidemic. It is curious the borer and the fungus have also gone hand in hand in the destruction of sugar-cane plantations wrought in Barbadoes, in Jamaica, in Mauritius, in British Guiana and in the United States. The pest first showing itself by the drying of the middle of the cane and the cane rotting away afterwards, the disease is known in Bengal both as *Májerá* and *Dhashá*. The former name should however be confined to the damage caused by the borer alone, the name of the borer insect being *Májerá-poká*. The name *Dhashá* may be similarly properly confined to the damage caused by the agency of the Trichosphœria fungus as the same name is applied to other fungoid diseases. Hard rinded canes which are comparatively free from the attack of the borer are also comparatively free from the attack of the fungus.

1,258. The parent moth lays her eggs upon the leaves of the young cane near the axils, and the young borer, hatching in the course of a few days, penetrates the stalk at or near the joint, and commences to tunnel through the soft pith. The growth of the larva is very rapid, and the full size is reached in a month. The full grown larva is about an inch

long, rather slender, nearly cylindrical, and cream white in colour, usually speckled with black spots, with a yellow head and black mandibles. On attaining its full size it bores a hole on the side of the cane for its future exit and then goes back into its tunnel and pupates. The slender brown pupa is about three-quarters of an inch long. In a few days the pupa becomes a moth and comes out of the hole already made in its larval stage. The moth is light greyish brown in colour and $1\frac{1}{4}$" from wing to wing when the wings are expanded. The hind wings of the male are silvery white. There are several broods in the course of the same season, and the larvæ are plentifully ensconced in the tops or cuttings sown, or the portions of the cane rejected and left neglected in fields. The hybernation takes place in winter in the larval and pupal stages, and the moths come out again in April or May.

1,259. The methods of keeping down the pest suggested by the above description are : (1) collecting all refuse leaves, tops &c. and burning them in a heap and (2) pickling the tops or cuttings sown with an aqueous and poisonous mixture consisting of soot, lime, ashes and arsenic made up into a thin mixture and leaving the canes dipped in it for a few hours before planting. If sulphate of copper solution instead of plain water is used as a simultaneous preventive against Trichosphœria fungus, the seed-canes should be kept dipped in the mixture only for a minute.

1,260. Thorough cultivation of soil is also useful ; but burning of the sod is not recommended as it disturbs nests of red ants which are a most useful natural agency in killing the borer.

1,261. Certain special methods are said to have been effective in keeping down the sugar-cane borer. These are :— (*a*) Collecting all leaves on which the eggs of the borer are seen and burning them. The eggs are brownish in colour and are deposited in groups of about 20, and children can be

taught to recognise them and afterwards employed in picking them from plantations. (*b*) Cutting out and burning all shoots or stems that appear withered or wanting in life. Children may be taught to do this also and they may be employed in plantations for this purpose. (*c*) Keeping lighted lanterns hanging in sugar-cane plantations at night, with shallow vessels of water and kerosine under them. By adopting this last device one can get rid of Noctuid moths and other insects in large quantities. In the month of *Kartik* (October and November), a custom prevails in this country of hanging up lights in the open at night. It may not be very difficult to induce cultivators to adopt the modified custom of hanging up lights in their fields with vessels of water underneath, during the month of *Kartik*, as it is during this month, as also in June and July, that moths &c. lay eggs and do the greatest amount of damage to crops, though the damage is most noticed later on in the season.

CHAPTER CXX.

WHITE-ANTS (TERMES TAPROBANES) AND OTHER ANTS.

THE *white ants* (Neuroptera) are well known social insects which make tunnels and galleries in homesteads and fields, and thus do a great deal of mischief. They destroy most of the ordinary timber except teak. They sometimes attack roots of living plants and trees such as sugar-cane plants and mango trees, gradually working their way upwards. The males and females are furnished with four large wings of equal size, but the workers or neuters have no wings. Their bodies are oblong and depressed. The queen will lay 80,000 eggs in a day for a long time, and the enormous growth a colony may undergo in a short time may thus be imagined.

As in the case of ordinary ants, the white-ants leave their nest for their "marriage flight" at the end of the rainy season, lose their wings, and a surviving pair after losing their wings, are led into the nest by the neuters, when the abdomen of the female becomes enormously distended with eggs, *i. e.*, two or three inches in length and more than half an inch in thickness (Fig. 73 *a*). She goes on laying about 60 eggs per minute. The larvæ from these eggs perform the greater part of the work of the nest, in making tunnels and galleries. The pupæ differ from larvae in possessing rudiments of wings. The "soldier" white-ants are distinguished by their larger head and powerful mandibles. They are probably neuters.

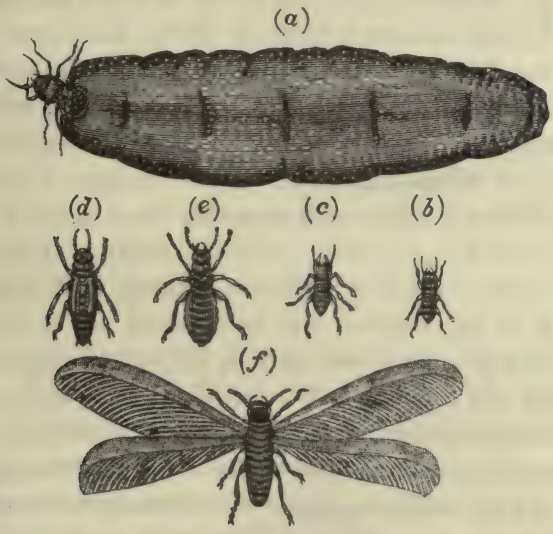


FIG. 73.—THE WHITE-ANT.

(*a*) Queen white-ant ready to deposit eggs.
(*b*) Working neuter.
(*c*) Soldier neuter.
(*d*) Male pupa.
(*e*) Female pupa.
(*f*) Winged white-ant.

1,263.—When white-ants attack the roots of ordinary

agricultural crops such as, sugar-cane, rice, jute, *arahar* and vegetables, a heavy shower of rain or thorough irrigation, proves the best remedy. When however they attack the roots of trees, it is difficult to get rid of them. Vigorously growing trees however are seldom attacked by white-ants. Liberal application of castor-cake, is the best remedy against this pest, as the insects dislike castor-cake, and the vigour imparted to the plants afford perhaps a further remedy.

1,264. Dr. Watt recommends the use of the "Gondal mixture" first prepared by the Thakore saheb of Gondal and used by him as a white-ant destroyer. It is a mixture of Dekamali (Gardinialucida) gum, asafœtida, bazaar aloes and castor-cake.

1,265. *Ordinary ants* (*the Formicidæ*,—order Hymenoptera).—Against ordinary ants of which there are several species, the following remedies have been found useful: (1) Attracting them with cocoanut kernels mixed up with sugar and then destroying them by drowning or otherwise from time to time. (2) Attracting them with a sponge dipped in a strong solution of sugar, and drowning them in hot water. (3) Strings dipped in corrosive sublimate solution (1:2,000) may be laid along corners of godowns whence ants make their approach or the solution may be brushed on to the whole floor. (4) Agave fibre mats are a protection against both white-ants and common ants. (5) Turmeric powder is very efficacious against red ants. (6) Of patent preparations reported favourably, may be mentioned the "Atlas preservative A". Messrs. Ewing and Company of Calcutta are the local agents for sale of this preparation. Even when applied to a living crop in the ground, which was badly attacked by white-ants, it had the effect of clearing the ground of the pest. It is also said to be a powerful weed destroyer, but how it can destroy weeds without destroying living crops, does not appear very clear. The efficacy of this preparation against white-ants, however, has been certified by Mr. P. Lancaster, Secretary

to the Agricultural and Horticultural Society of India, who undertook the experiment at the request of the Bengal Agricultural Department.

1,266. Ordinary ants (formicidæ) belong to a different order altogether from white-ants, the former coming under Hymenoptera and the latter under Neuroptera. There are several sub-families of the Formicidæ, the Formica sacchari-vora (*Gondo-pimpra*), the Formica fuliginosa (the common jet black ant) and the Camponotus sericeus (the ordinary big black ant). The Camponutus smaragdinus (*Kat-pimpra*), a greenish and large sized ant which lives on trees and makes large sized nests of live leaves connected by a white web, belongs to the sub-family Formicidæ, while the ordinary red house-ant (Diplorhoptrum molestum) belongs to the sub-family Myrmicinæ, which are armed with a sting. The Formicidæ though stingless often bite very sharply (*e.g. Kat-pimpra*). Those who wish to study the interesting subject of social insects, "Ants, Bees, and Wasps" should read the book bearing this name written by Sir John Lubbock.

CHAPTER CXXI.

THE MANGO WEEVIL (CRYPTORHYNCHUS MANGIFERA).

THIS weevil (Fig. 66*d*, *d*, *d*) which is very much larger in size (about ¼ of an inch being its length) than the granary weevil, belongs to the family Curculionidæ of the order Coleoptera. It can be cut open from many ripe mangoes, specially those hailing from Eastern Bengal, where it occurs very plentifully. The weevils are black when they newly come out of a fruit, but on drying they assume a rusty-brown colour. The larvæ are white, fat, with fleshy tubercles instead of legs. As both larvæ and pupæ as well as imagoes can be got out

from the same mango, the pupal stage cannot last long The hybernation through the autumn and winter months evidently takes place in the imago stage, though it has not been discovered where the insects lie concealed through all these months. But they are noticed in May, June and July flying about. Whether these are the last season's weevils or fresh weevils from early fruits, is not known. It is not known exactly whether the oviposition takes place on flowers or young fruits. No hole or pustule of any kind is noticed on the surface of affected fruits.

1,268. The remedies suggested are :—(1) Cultivation of land under mango trees and growing turmeric, or ginger, or some such aromatic plant that will grow well in shade. (2) Letting poultry in after cultivation but before sowing of seed. (3) Allowing servants and others habitually to cook under the affected trees. (4) Carefully removing and destroying all stray fruits, stones, rind and refuse of mango trees generally. (5) Keeping crevices and holes in the trunk of the mango trees plastered over or otherwise obliterated. In Europe trunks of valuable trees are painted or tarred, to protect them from insect pests. It is possible the weevils hybernate in the crevices of the trunk, and the effect of painting the trunks on a large scale may be watched in some Eastern Bengal district.

1,269. The larva of a dipterous insect (Dacus ferrugineus) spoil late ripening mangoes in certain localities. The Malda mangoes growing in the Katgola garden in Murshidabad are annually spoilt by these maggots. The remedies recommended for this pest are the same as for the weevil. Probably the oviposition in the case of the weevil takes place when the trees are in full blossom, and in the case of the maggot, just before the fruits ripen. Spraying of Kerosine emulsion or asafœtida water, for the purpose of producing a stink in the vicinity of trees one wishes to protect from the flies, is the treatment indicated in the case of the maggot. The

spraying should be done when the fruits are still green but properly developed.

CHAPTER CXXII.

THE INDIAN GOLDEN-APPLE-BEETLE. (Aulacophora Abdominalis.)

THIS is a Coleopterous insect belonging to the family Chrysomelidæ. It destroys various Indian crops and in its turn it is usually destroyed by a Coccinellid beetle known as Palæopeda sex-masculata. We have noticed both these insects in the Sibpur Farm on cotton, gourd, melon and cucumber plants. Water melons, *jhingas* and *palval* creepers growing in the same field were not attacked. In the Saharanpur Botanical Garden it was found to be generally destructive to all Cucurbitaceous plants. It is said to attack the floating water-nut plants (Trapa bispinosa) also. The beetle is a little under half an inch in length, brilliant reddish yellow in colour; the wings are yellow and do not entirely cover the abdomen. The legs are reddish yellow. The under-surface is partly yellow and partly black.

CHAPTER CXXIII.

PLANT-LICE AND SCALE-INSECTS (APHIDES AND COCCIDÆ).

THESE homopterous insects are very destructive. Plant-lice (aphides) are more destructive to agricultural crops than scale-insects. The commonest aphis of Bengal is the

jáb poká (Aphis brassicæ) of the mustard crop. Aphides are also known to attack potatoes, cabbages, cauliflowers tobacco, *arahar*, turnip, radish, &c. An aphide which produced curling and twisting of leaves of the tobacco plants grown at the Sibpur farm in 1892 93, was identified as Siphonophora scabiosa. The coccinelidæ beetles (lady-birds) that preyed upon these were identified as Chilomenes sex-maculata. Another aphide which causes injury to the mustard and rape crops, was identified by the authorities of the Indian Museum as Rhopalosiphum dianthi. The females which are generally wingless are viviparous, their abdomen being transparent, the yellow young embryos may be seen through the green skin of the abdomen. The colour of the insect, however, is not always green, but it is sometimes ocherous red, or brown, or yellow, or black. The pupæ and the larvæ can hardly be distinguished. The wing-cases of the pupæ are tipped with brown and the points of antennæ are also brown. The larvæ are the most voracious. Males are very rare, and for a number of generations their help is not required for fertilization. The asexual larvæ usually develop into wingless females. The fully mature sexual forms have prominent wings but they also are propagated asexually. The blackish tea-aphis has been already spoken of.

1,272. The belief that blights, that is the appearance of aphides and coccidæ insects, are due to fog or east-wind, is common not only in this country but also in England, but it is a mere superstitious belief. The extraordinary multiplication of the aphides gives one the idea that they appear all of a sudden, and their apparent sudden appearance is accounted for in some fanciful way. Suppose one little aphis produced from an egg deposited last autumn should appear in spring on a bean creeper when it is just budding. She gives birth say to 10 young aphides each of which is a female. In a few days these ten females without any connection with a male will each produce another 10 agamogenetic females. If the

weather is fine and the aphides are not tracked by ants or other insects, and if the bean-stalk continues flourishing, this agamogenetic propagation will go on every 4 or 5 days for about 12 generations, the rate of increase being, say 10 in every case. If a calculation is made it will be found that in less than two months from one aphis one billion may be produced, and if the rate of increase be 100 instead of 10, the number comes to something enormous. The last generations are partly male and partly female, the intermediate generations being wingless and imperfect females. The male and female pair and lay eggs in the autumn or in the cold weather and from these eggs come males and females of the following spring.

1,273. *The Scale-insects.*—The Aleurodes which invade rose bushes, orange trees, sugar cane plants; the Icerya which spoil various fruit trees &c.; the Dactylopius, one species of which causes the disease known as *tukra* to mulberry trees, and other coccid insects, are preyed upon in their turn by lady-birds (coccinellidæ) beetles. But the latter are unable to cope with the insects when they become too numerous, when Kerosine emulsion and other special remedies already described, may be tried with success. Ants also are of great benefit in devouring and killing scale-insects.

1,274. Scale-insects do considerable damage to fruit trees and other perennials, but they do not do such damage to ordinary agricultural crops as the other hemipterous insects (aphides) we have just described. There are several scale-insects, on the other hand, which manufacture some important economic products. Cochineal and lac are produced respectively by Coccus cacti and Coccus lacca. Manna is the gummy secretion of the tamarisk tree which are punctured by Coccus manniparus. The white wax of commerce is produced by Erioceruspela, a Chinese scale-insect. There is an Indian scale-insect also (Ceroplastes ceriferous) which yields a white wax. The females of scale-insects are always

wingless, and they are scale-like. The male is provided with two wings, but as in aphides, their presence is not always necessary for the formation of embryo.

1,275. Coccinellid beetles are very useful in devouring scale-insects and aphides. It should be remembered, however, that they are not invariably friends to the cultivator. The larvæ of Epilachna dodeca-stigma attack the leaves of brinjal plants and sometimes do a great deal of damage.

1,276. For aphides and scale-insects the Kerosine emulsion treatment generally proves most efficacious. One part of Kerosine oil to 80 or 100 parts of water should be used. The oil should be mixed up with equal quantity of fresh-milk or butter-milk (*ghól*) and thoroughly worked up with a syringe or shaken up in a bottle to saponify the oil, before it is mixed up with water and applied with a spray-pump.

CHAPTER CXXIV.

INSECTS INJURIOUS TO INDIAN CROPS.

Paddy.

1. Cockchafer larvæ (Melonthini, order Coleoptera.)
2. Lasioderma testaceum, or the cheroot weevil (Ptinidæ, Do.)
3. Calandra Oryzæ (Curculionidæ, Do.)
4. Platydactylus sexspinosus (Scolytidæ, Do.)
5. Hispa Aenescens (Chrysomelidæ, ... Do.)
6. Aulacophora abdominalis (Chrysomelidæ, ... Do.)
7. Chætocnemis basalis (Chrysomelidæ, ... Do.)
8. Suastus gremius (Hesperidæ, or skippers, ... Lepidoptera).
9. Limacodidæ caterpillars (Nettle-grub-defoliator, Do.)
10. Achæa melicerte (Noctues, ... Do.)
11. Heliothes armigera (Noctues, ... Do.)

12. Leucania Extrania (Noctues ... ... Lepidoptera.)
13. Do Loreyi (Do., ... Do.)
14. Paraponyx oryzalis (Hydrocampidæ, Micro-lepidoptera.)
15. Chilo oryzæellus (Crambidæ ... Do.)
16. Cecidomyia oryzæ (Cecidomyidæ, ... Diptera.)
17. Leptocorisa acuta (Rhynchota, ... Hemiptera.)
18. Physopelta schlaubuschii (Rhynchota, ... Do.)
19. Catantops axillaris (Acrididæ, ... Orthoptera.)
20. Hieroglyphus furcifer (Acrididæ, ... Do.)
21. Euprepocnemis bramina (Acrididæ, ... Do.)

Wheat.

1. Trogosita mauritanica (Trogositidæ, ... Coleoptera.)
2. Arthriostoma undulata (Dermestidæ, ... Do.)
3 Rhizopertha pusilla (Ptinidæ, ... Do.)
4. Opatrum depressum (Tenebrionidæ, ... Do.)
5. Calandra Oryzæ (Curculionidæ, ... Do.)
6. Agrotis suffusa (Noctues, ... Lepidoptera.)
7. Chilo oryzæellus (Crambidæ, ... Do.)
8. Crotogonus sp. (Acrididæ, ... Orthoptera.)

Barley.

1. Agrotis suffusa.
2. Crotogonus sp.

Oats.

1. Leucania extrania.
2. Agrotis suffusa.

Jowar.

1. Silvanus surinamensis (Cucujidæ, ... Coleoptera.)
2. Rhizopertha pusilla (Ptinidæ, ... Do.)
3. Epicauta rouxi (Cantharidæ, ... Do.)
4. Epicauta tenuicollis (Cantharidæ, ... Do.)

Maize

1. Chilo Simplex (Crambidæ ... Lepidoptera.)
2. Gelechia cerealella (Plutellidæ, ... Microlepidoptera.)
3. Hieroglyphus furcifer.

Panicum miliare.

1. Euprepocnemis bramina.

Bajra.

1. Crotogonus sp.

Sugar-cane.

1. Xyleborus perforans, *beru pokâ.* (Scolitidæ, ... Coleoptera.)
2. Mancipium nepalensis (Pierinæ, ... Lepidoptera.)
3. Achæa melicerte (Noctues, ... Do.)
4. Scirpophaga auriflua (Microlepidoptera, ... Do.)
5. Chilo simplex, *majera-pokâ*
6. Dragana pansalis (Deltoides, ... Do.)
7. Œdalus marmoratus (Acrididæ, ... Orthoptera.)
8. Pœcilocera hieroglyphica (Acrididæ, ... Do.)
9. Termes taprobanes (Termitidæ,... ... Neuroptera.)
10. Dorylus, orientalis, driver ant (Formicidæ, ... Hymenoptera.)
11. Blissus gibbus (Clinch-bug, Hemiptera.)
12. Ripersia sacchari (Scale-insect, Do.)

Gram.

1. Aulacophora abdominalis.
2. Mancipium nepalensis.
3. Parasa sp. (Limacodidæ, ... Lepidoptera.)
4. Agrotis suffusa.
5. Plusia nigrisigna (Plusidæ, noctues ... Do.)

Arahar.

1. Bruchus Chinensis. (Bruchidæ, ... Coleoptera.)
2. Achæa melicerte.
3. Eriochiton cajani (Coccidæ, ... Hemiptera.)

Brinjal.

1. Epilachna viginti-octo-punctata.
2. Achæa melicerte.
3. Chilo sp.
4. Lencinodes Orbonalis (Microlepidoptera.)

Cucurbitaceous crops generally.

1. Aulacophora abdominalis.
2. Epilachna viginti-octo-punctata.
3. Carpomyia parctalina (Muscidæ,... ... Diptera.)

Jute.

1. Spilosoma sp. (Archtiidæ, ... Lepidoptera.)
2. Noctuids.

Cotton.

1. Sphonoptera gossypii (Buprestidæ, ... Coleoptera.)
2. Aulacophora abdominalis.
3. Heliothis armigera.
4. Dipressaria gossypialla (Plutellidæ, ... Microlepidoptera.)
5. Dysdercus cingulatus (Rhynchota, ... Hemiptera.)
6. Oxycarenus lugubris (Do. ... Do.)
7. Lohita grandis (Do. ... Do.)

Mustard.

1. Agrotis suffusa and other noctuids.
2. Aphis brassicæ (Aphidæ, ... Hemiptera.)

Linseed.

1. Opatrum depressum.
2. Mancipium nepalensis.
3. Agrotis suffusa.
4. Crotogonus sp.

Indigo.

1. Haltica nigrofusca (Chrysomelidæ, ... Coleoptera.)
2. Agrotis segetum.
3. Psylla isitis (Psyllidæ, ... Hemiptera.)
4. Crotogonus sp.

Rabi crops generally.

1. Heliothis armigera.
2. Apinis concinna (Rhynchota, ... Hemiptera.)
3. Fuligoridæ (Lantern flies ... ... Do.)

Kharif crops generally.

1. Epacromia dorsalis (Acrididæ,... ... Orthoptera.
2. Heteropternis sp. (Do. ... ... Do.)

Standing crops generally.

1. Aloa lactinea (Arctidæ, ...Lepidoptera,—fluffy moths, with hair covered, defoliating caterpillars.)
2. Spilosoma sp. (Arctiidæ, ... Do.)
3. Spaliria minor (Lasiocampidæ,... Do.)
4. Heliothis armigera.
5. Agrotis segetum (Noctuidæ, ... Do.)
6. Agrotis suffusa.
7. Acridium peregrinum (Acrididæ ... Orthoptera.)
8. Acridium succintum (Do. ... Do.)
9. Acridium melanocorne (Do. ... Do.)
10. Acridium æruginosum (Do. ... Do.)
11. Caloptenus erubescens (Do. ... Do.)
12. C. caliginosus (Do. ... Do.)
13. Cyrtacanthacris ranacea (Do. ... Do.)
14. Oxya furcifera (Do. ... Do.)
15. Oxya velox (Do. ... Do.)
16. Pachytylus cinerascens (Do. ... Do.)

17.	Crotogonus sp.		
18.	Pœcilocera picta	(Acrididæ	Orthoptera.)
19.	Hieroglyphus furcifer.		
20.	Tryxalis turrita	(Do.	Do.)
21.	Atractomorpha crenulata	(Do.	Do.)
22.	Mecopoda sp.	(Do. ...	Do.)
23.	Euprocnemis bramina	(Do. ...	Do.)

CHAPTER CXXV.

ZYMOTIC DISEASES AND REMEDIES FOR THEM.

WHEN an agricultural crop or herd of animals dies out in abundance without any apparent cause, the loss may be supposed to be due to some microscopic organism. Potato-rot, wheat-rust, cattle-plague, animals dying suddenly after a swelling in the neck, are examples of loss due to micro-organisms. When one notices any crops or animals dying from some mysterious cause, one should take some fluid out of a recnetly dead plant or animal from an organ that appears to have undergone special decay. If the diseased organ or tissue is too dry to yield any fluid, it should be macerated with a little clean water and the fluid thus made taken into a glass slide. The fluid should be spread out then on a cover-glass and mounted in the usual way. The specimens may then be examined leisurely for identification of the epidemic. For certain epidemics protective inoculation has been found beneficial, as for instance, (1) for anthrax, (2) for fowl-cholera, (3) for charbon symptomatique (called also quarter-ill, black-quarter, braxy of sheep and gloss-anthrax,—the disease of horses and cattle called *Galáphulá*) and (4) rabies. Protective inoculation for animals can be carried on in this country if the plagues are identified.

1,279. For another class of zymotic diseases another form of remedy has been applied with success. The method of combating these diseases consists in the destruction of the organisms producing the disease. No exact information is available as to the origin and growth of these parasites ; in other words, we cannot trace in every case of epidemic the origin of the germs associated with them at their first occurrence and how they are afterwards conveyed into the bodies of animals and plants through the vehicles of wind, water, leaves, grasses &c. That every case of decaying fruits, flowers, leaves, and specially animal matter and excreta, is associated with numerous microscopic organisms, can be easily seen under the microscope. That germs of putrefaction are in some cases productive of disease, has been also established without doubt. We can see for ourselves that if we allow vegetable matters, excreta, dead animals &c., to rot in considerable quantities near human habitation, fatal diseases break out among men. It has also been proved that all epidemics are associated with certain microbes. The connection between epidemics among animals and plants and the putrefaction of vegetable and animal substances is therefore very close, *viz.*, one of cause and effect. It is not certain, however, in every case of epidemic where exactly the putrefactive germs originated and became converted into pathogenic germs. The main principle on which the prevention of epidemics both among plants and animals is based, consists in the prevention of putrefaction of organic matter. We often find fields submerged under water at the end of the rainy season for a long time, a condition which is helpful to putrefaction of the grasses &c. which are afterwards consumed by cattle. Such lowlying lands are only too common in Bengal. Bacteriologists have discovered the germs of anthrax in rotten grass. English and Scotch agricultural lands are usually drained and the ravages of anthrax in these two countries have been minimised in consequence. Want of

proper drainage is the chief cause of the prevalence of anthrax in this country. A field submerged for a considerable period under water should not be used for grazing cattle on, for at least 2 months afterwards. The neck-swelling disease (or gloss-anthrax) is also probably caused by cattle grazing on fields of this kind where very coarse grass grows. Such fields should not be too readily used for growing crops on, either. They should be well dug up or cultivated in the cold weather and exposed to the burning sun of April and May, before they are used for cropping. Well cultivated soils exposed to the rays of the sun for several days together in April or May most likely become free from all dangers arising from the disease-producing germs, as continuous application of heat and light kills these germs.

1,280. Some general rules for prevention of epidemics are given below:—

(*a*) As soon as a contagious disease is noticed, cleaning of jungles, re-excavation of tanks, cleaning of sewers and disturbance of putrid matter generally, should be stopped. One should be always careful about cleaning sewers, jungles, tanks &c. beforehand. But when a disease takes an epidemic character the attempt to remove nuisance often causes the spread of the disease all the faster. When an epidemic has broken out it should be inferred that putrefactive processes somewhere have gone too far and that the germs have now become mixed up with the air that is breathed, or the water that is drunk, and the disturbance of filth at this stage is likely to cause a greater admixture of such germs with water and air. Instead of disturbing these possible sources of infection, it is best to treat them with germicidal substances, *i. e.*, sprinkle sulphate of copper, alum, or corrosive sublimate solution over them.

(*b*) If in a herd of cattle one is found attacked with a zymotic or infectious disease, the affected animal should *not* be removed elsewhere, but only the healthy animals.

(*c*) When removing the healthy animals, their bodies should be washed with a $\frac{1}{4}\%$ solution of sulphate of copper and they should be made to swallow a little of ferrous sulphate with ginger ($\frac{1}{2}$ ounce of the sulphate being given to an ox).

(*d*) When an epidemic breaks out in potato, wheat or any other agricultural crop, the crop should not be removed after harvest, but some arrangement should be made to store it in the field in which they have grown.

(*e*) Seeds of all kinds should be pickled before sowing. For delicate seeds steeping in camphor water is recommended for 2 hours, and for ordinary agricultural seeds, such as wheat, paddy, sorghum, potatoes, the sulphate of copper dip is the best. Immediately after the dip, the seed should be got dry with lime and ashes which have also germicidal properties, and then sown. There is very little chance of a crop suffering from a fungoid disease if the seed has been pickled in this way before sowing, and the sowing done in a field in or near which this particular disease has not been noticed for about two years.

(*f*) Animals and plants enjoy some amount of immunity from epidemics if they are kept in a vigorous condition. For vegetables, water and manure, and for animals, oilcakes, pulses, wheat-bran, salt, fenugreck and sugar, are invigorating and stimulating foods. A vigorous constitution is generally speaking unsuitable for the growth of parasites.

(*g*) When an epidemic breaks out among animals, one should not rest satisfied simply by removing the healthy animals and giving them stimulating food. They should be given with their food some germicidal substance for a few days until the danger is passed. The affected animal should be also encouraged to eat some food in which some germicidal substance is mixed up. These are, quinine, sulphate of iron, sulphate of copper, lime, corrosive sublimate (*rasa-*

karpur), camphor, mustard oil, borax, arsenic, mint, lemon, butter milk, pepper, vinegar, etc. Any one or more of these substances can be easily procured in any part of the country, and one or more can be used according to local convenience. Of these, corrosive sublimate, arsenic and quinine, are very poisonous and should not be used at all without veterinary advice or used only in very minute quantities. No better germicidal substances can be named, which may be commonly used, than mustard oil, lime juice, sulphate of iron and vinegar. A substance is protected from most putrefactive germs if mustard oil is mixed with it in proportion even so low as 1 to 2,000. Mustard oil should not be confounded with colza or rape oil which is in common use for culinary and other purposes; but ordinary Indian mustard oil in larger proportion is effective. The use of mustard oil and fresh lime juice and sour milk as common accessories to rice meal cannot be too highly spoken of. *Gowálás* in Bengal speak of their deriving some benefit from mustard oil, sour milk and pepper in cattle plagues.

(*h*) When an animal or plant dies of an infectious disease, it should be dipped in sulphate of copper solution before putting it to use as manure, etc. The animals that die in M. Pasteur's laboratory are thrown into a vat of sulphate of copper solution. They are removed by farmers for use as manure after they have been in the vat for only 24 hours. This treatment of carcases containing germs of most deadly diseases prevents their doing harm by the spread of infection. If anthrax vaccine or any other fluid containing pathogenic germs is accidentally spilt in this laboratory a little of the sulphate of copper solution is spread or sprinkled on the spot which makes the spilt liquid quite inoccuous. A list of germicides including the proportion which usually suffices to kill the germs or inhibit their growth in each case, is given below. The same proportion is not applicable in the case of every germ and it is safest to use a

stronger solution in every case. Some of these have been experimented with only in the case of cholera bacillus. Others have not been experimented with on any pathogenic germ, but only on the ferment of sugar-water or of wine (bacillus aceti) or some such harmless germs. So the following table will only give a rough idea as to the proportion in which different germicides should be used.

1,281. Sugar has the effect of inhibiting the growth of bacillus anthracis. The use of sugar or molasses should therefore be freely resorted to in the treatment of anthrax and in feeding of animals when this epidemic is raging. Salt also has germicidal properties and the use of salt which is in vogue in Bengal in the treatment of anthrax (*gobasanta*) is to be considered quite rational.

Iodide of mercury	1 to 200,000
Bichloride of mercury (corrosive sublimate)	1 to 100,000
Nitrate of Silver	1 to 50,000
Hydrogen peroxide	1 to 8,000
Iodine	1 to 6,000

[Koch has ascertained that 1 to 100 of iodine is required to kill the germs of cholera.]

Sulphate of Quinine	1 to 5,000
Iodoform	1 to 5,000
Napthaline	1 to 4,000
Sulphate of copper	1 to 2,500
Mustard oil (English)	1 to 2,000
Salecylic acid	1 to 2,000
Cinnamon oil	1 to 2,000
Permanganate of potash ...	1 to 1,000
Eucalyptus oil	1 to 600
Carbolic Acid	1 to 500
Hydrochloric acid	1 to 500
Borax	1 to 350
Camphor	1 to 300
Arsenic	1 to 250

Chloride of zinc	...	... 1 to	250
Lactic acid	...	... 1 to	125
Carbonate of sodium	...	... 1 to	100
Alcohol ...	...	... 1 to	10

CHAPTER CXXVI.

AGRICULTURAL BACTERIOLOGY.

PROFESSOR Hankin of the Agra Bacteriological Laboratory reported a few years ago, that the water of the Ganges and the Jumna contained nearly a thousand microbes to the cubic centimetre, that is, in about a quarter of a tea spoonful. In European bacteriological laboratories they usually find one to two hundred thousand microbes per cubic centimetre of water. Even ordinary good drinking water usually contains about 100 microbes to the cubic centimetre. As is the water, so is the air and the earth teeming with microbes. Generally speaking they are harmless ; but occasionally the air, or the water, or milk, or even the earth, teems with germs which are capable of producing epidemics. A cubic yard of country air contains from 50 to 350 germs, while a cubic yard of city air, contain over 2,000 germs, and the air inside houses contains over 5,000 germs per cubic yard, specially where there is carpet or mat used in the rooms. An ounce of street dust may contain over 30 million living germs. The superficial layers of soil also teem with bacteria. There may be hundreds of thousands in a single grain of superficial soil, but at a depth of 10 to 20 ft. there are no microbes. On the top of high mountains and in mid-ocean the air is free from microbes, and spring water is also free. The usual source of microbes is

fermentation. When juices of fruits are fermented for making wine, when cooked or uncooked meat or vegetables get spoilt, when milk gets sour, when curd of milk is ready for churning, when cheese is getting ripe, special microbes are generated. These are either useful or harmless microbes. But it is by similar processes of fermentation, souring, or spoiling, that germs capable of producing diseases in plants, animals and man, are generated. It is said, that in the battle-field 16 soldiers die from enteric fever and other pathogenic diseases to every one killed by a bullet. A knowledge of microbes helpful and inimical to agriculture is thus of very great importance.

1,283. *Enzymes.*— True ferments must be distinguished from enzymes which are elaborated from protoplasm and which have the power of making food substances soluble. Many foods are insoluble in water, and as plants including microbes are not able to utilise food except from solutions, the food substances utilised by plants are first decomposed and then absorbed. Absorption of food substances in the alimentary canals of animals, similarly takes place after decomposition effected by enzymes. To distinguish them from microbes, enzymes are called unorganized ferments. Enzymes are insoluble in alcohol but soluble in water and they must be in solution to be able to do their work of decomposing food substances. In the saliva, for instance, there is an enzyme which dissolves starch converting it into sugar. In seeds also there is an enzyme, called diastase, which is capaple of converting starch into sugar. There is another enzyme called pepsin, in the stomachs of higher animals, which has the power of dissolving meat in the presence of an acid. In the intestine there is an enzyme which is able to dissolve meat in the presence of an alkali. Enzymes do not diminish or increase in amount (like microbes) in doing their work. They do their work best in the presence of moisture at a temperature of about 98° F. Heating to the boiling point

destroys their power. In these two respects they resemble microbes.

1,284. *Microbes* or ordinary ferments are living organism which are capable of growing and multiplying. They also cause fermentation. With a high power microscope they can be actually seen. Enzymes themselves are the product of microbes.

1,285. *Fermentation.*—Fermentation is divided into three classes :—(I) Fermentation proper *e. g.*, (*a*) Vinous or saccharine fermentation caused by the yeast fungus and certain moulds resulting in the production of alcohol ; (*b*) Acetic fermentation caused by the microderma aceti fungus acting on alcoholic solutions ; (*c*) Lactic fermentation caused by Bacillus lactis acting on the sugar of milk ; (*d*) Butyric fermentation caused by the Bacterium butyricus acting on the fat globules of milk. (II) Putrefaction or growth of saprophytic rot-germs on dead bodies of plants or animals. This is accompanied by the production of mal-odorous gases containing sulphur, phosphorus, &c., also of toxines, ptomaines, &c., which are highly poisonous substances. A putrefactive germ produces in milk (or in ice-cream) a toxine called tyrotoxicon which is able to poison people to death. (III) Pathogenic fermentation is caused by disease producing germs living in the tissues of plants and animals. They also produce toxines or poisonous substances which are highly deliterious to the life of the plant or the animal. It is not by the blocking up of capillaries caused by an abundant growth of Bacillus anthracis, but by the production of a poisonous substance by a few of the Bacilli, that the animal dies so suddenly when it is attacked by anthrax. (IV) Fermentation caused by unorganised ferments must be distinguished from the above three classes of true fermentation caused by microbes.

1,286. *Antitoxin treatment.*—The fever which accompanies most diseases due to pathogenic microbes is the

result of a fermentation caused by a toxine or poison secreted by the microbes. In the effort to counteract the poison the tissues burn more vigorously, *i.e.*, consume more oxygen. Hence the utility of giving plenty of fresh air to animals suffering from pathogenic diseases. The products of combustion carrying away the poison are excreted by the kidneys and the sweat-glands. The toxines separate themselves out from the microbes in urine, sweat, bile, &c., and it has been found that the toxines injected into the blood of animals have the power of producing fermentation as evidenced by fever. The toxines separated from the microbes have been found in some cases most useful prophylatic agents against those very diseases which are caused by those microbes from which the toxines were derived. In two diseases, *viz.*, diphtheria and glanders the 'anti-toxin treatment,' has proved most valuable. Dr. Roux's Diphtheria Serum is prepared by first cultivating the pure virus or germ of diphtheria in meat broth for some weeks. The liquid portion is then filtered off from the bacilli and the clear liquid is injected under the skin of a horse. Minute doses are used at first, but after a time the animal is able to withstand large doses, and it then becomes immune against the disease. The blood-serum of a horse thus immunised is the valuable cure for diphtheria which is now in general use in Europe. The substance called Mallein which is used for diagnosing and sometimes also for curing glanders, is a fluid similarly prepared. Glanders is communicable not only from horse to horse, but also to human beings, dogs, goats, donkeys and mules. It is a disease caused by a bacillus (Bacillus mallei) which appears in the form of an obstinate running cold. Another form of this disease is called Farcy in which the skin of the face and neck of the horse is affected by streaky sores. The bacillus can be collected from inside these sores and cultivated in broth at the temperature of 98°F. for 30 days. The culture is afterwards

sterilized at the boiling temperature for one hour. Then the dead bacilli are separated out from the liquid portion and the liquid portion (which is called mallein) is used for diagnosing the disease in suspicious cases (when an injection developes the disease) or in very small and repeated doses, for curing the disease. Once cured, even a strong dose of mallein does not cause fever in the animal into which the fluid is injected. For diagnostic purposes the use of another toxine is also of some interest to agriculturists. Professor Koch discovered that tuberculin, *i. e.*, the serum separated out in the above described manner from a culture of Bacillus tuberculosis, when injected in small doses into cattle afflicted with tuberculosis, produces fever, while a similar dose injected into an animal which is not so suffering, produces no reaction. This is thus a good means of detecting tuberculosis in cattle. In the case of cholera the investigation of Professor Rudolf Emmerich of Munich and Dr. Ziro Tsuboi his Japanese colleague, tend to show that the active principle in this disease also is a toxine, which is probably nitric acid, as the symptoms of cholera and the symptoms of nitric acid poisoning closely resemble each other.

1,287. In *classifying microbes*, however, this principle of division according to the nature of fermentation each produces is not taken into account, but stress is rather laid on the appearance and form of the organism, under the microscope. The simplest form of the microbe is the coccus or spherical form and those which retain this form to the last are known as *micrococci.* Micrococci, however, become slightly elongated and then dumb-bell shaped before dividing themselves each into two. But the general appearance of a cluster of micrococci is that of minute little spheres. If the general appearance of a cluster of microscopic fungi indicates elongation, *i. e.*, if most of the microbes in the cluster instead of being spherical are spindle shaped, or like short rods, in appearance, then they

are to be recognised as *Bacteria* and not micrococci. If the general appearance of a group of microbes is that of bits of thread or cylindrical rods of different lengths, these are to be identified as *Bacilli*. These may be straight bent or curved, fine or fairly plump, of the same thickness throughout or beaded or knot-like in appearance. When the bacilli are serpentine (*i.e.*, made up of small S's) they are to be recognised as *Vibrios*; and when they are cork-screw shaped they are called either *spirilla* or *spirochætæ*. If the cork-screw shaped thread does not bend but remains straight while moving it is called a spirillum, but if it is seen to bend as most of them do when they are observed under the microscope, it is called a spirochætæ. The common bacillus of cholera is to be classed as a spirillum, representing part of one turn only.

1,288. Besides these simple forms, *viz.*, micrococcus, bacterium, and bacillus (with its variations of vibrio, spirillum, and spirochætæ), there ate complex forms under each group. Where the micrococci usually occur in pairs, they are called diplococci. The microbe of fowl-cholera (*guti*) is a diplococcus. When micrococci occur in chains they are called *streptocoeci*. When they occur in groups of four they are called tetrads or tetra-coccus. Where they occur in the form of cubes or square clusters, they are called *sarcinæ*. Where they occur in irregular masses, they are called *staphylococci*; and where they occur in large uninterrupted masses in the form of slime or scum, they are called zooglœa. The cocci in each case may be either simple or flagillated or ciliated. Flagillated bacteria, micrococci and bacilli, also spirilla, move very fast. The germs of typhoid and of colic have cilia on their sides and hence they look like centipedes or spiders under the microscope. Bacteria also occur singly or in pairs and they are also sometimes flagillated. Bacterium termo, the ordinary germ of putrefaction, usually occurs as a double spindle provided with flagella

Bacilli and other thread-shaped microbes growing very long either in a straight or crooked manner, are called leptothrices, and when they branch they are called cladothrices.

1,289 The unit of *measurement* of bacteria is $\frac{1}{1000}$th of a millimeter, which is equal to $\frac{1}{25000}$th, of an inch, and it is represented by the letter μ. The length of bacteria usually varies from 2 to 10 μ., and the breadth from $\frac{1}{10}$ to 2 μ. The Bacillus anthracis rods are about 1 μ. in diameter. Yeast cells are about 10 μ. in length. With the help of micrometers, measuring of bacteria is done at the same time as microscopic observation. The dimensions of a microbe may be also judged by comparison with those of certain microbes whose dimensions are known to the observer.

1,290. *Reproduction.*—Yeast cells are budding-fungi, whereas bacteria are fission-fungi, and it is better to call all the groups of bacteria, *viz.*, micrococci, bacteria and bacilli, by the generic name of Schizomycetes, than by the name of bacteria or bacilli, though it is difficult not to use either of the latter words as the generic name, as in popular language they are all called either bacteria or bacilli. Besides reproduction by gemmation or budding which takes place in the case of yeast fungi, and reproduction by fission which takes place in the case of Schizomycetes, there is another method of reproduction, *viz.*, by spore-formation. Yeast fungi usually have four spores formed in each. Bacilli and spirilla usually have several spores in each. Micrococci do not form spores. Some bacilli, *e.g.*, anthrax bacilli, require free access of air and a temperature of between 70°F. to 105°F. for free formation of spores. These are called ærobic germs. Those that thrive only when oxygen is excluded, *e.g.*, the bacillus of tetanus, are called anærobic germs. Others again thrive either with or without oxygen. These are called facultative germs, their ærobic forms being different from their anærobic forms. When anærobic germs are cultivated, they are found to generate mal-odorous gases.

1,291. Some germs *e.g.*, the germs of putrefaction, are only saprophitic and not parasitic. They flourish best at the temperature of 75° to 85°F., while parasitic miscrobes grow best with a temperature of 98° to 104°F., *i.e.*, the temperature of the animal body. Most microbes stop growing below a temperature of 48°F., and a few are destroyed by freezing, though the majority of microbes only remain quiescent at low temperatures and do not actually lose their vitality. Under repeated thawings and freezings they succumb more quickly. But spores of anthrax survive even this treatment. In the sporular condition, microbes stand high temperatures also much better, though most of them lose their vitality in their vegetative condition subjected for ten minutes to the dry heat of 120°F. They can stand moist heat better than dry heat, and if it is intended to destroy microbes by the use of hot water, or by heating milk or other liquids which are likely to contain microbes, it is necessary to bring up the temperature to 150°F. Some microbes which live in the soil can resist the temperature of even 165°F. Parasitic microbes are more readily killed by heat than saprophitic microbes, and the action of disinfectants in killing the former is much enhanced if they are applied hot. Dr. Heider of Berlin showed how the spores of anthrax resisted the action of a 5% solution of carbolic acid for 36 days in the ordinary European temperature, but the solution raised to a temperature of 125°F., was sufficient to kill the spores in a few hours. That weak disinfectants are more effective when they are used hot, is a fact of great economic importance. Soap is a weak disinfectant, but hot soap water is a very effective substance to use for washing soiled clothes, etc. Saprophitic germs must be subjected to a heat of 250°F., for 10 minutes before they are killed. In the ordinary boiling temperature of water it requires 6 hours to kill some of the spores of putrefactive germs. Exposure to heat not sufficient to kill disease producing germs may yet attenuate

their virulence. This fact is also of great economic importance, as probably the heat of the sun makes most of the germs which would otherwise produce epidemics, more or less harmless. The action of sunlight, specially in the presence of air, in destroying microbes is also recognised. M. Moment of the Pasteur Institute exposed the bacilli of anthrax to sunshine both in the presence and absence of air, with the result that while those exposed to the sun in the presence of air were killed in 2½ hours, those placed in a vacuum were still alive after 55 hours' exposure to sunshine. The rays of the sun that have most effect in destroying microbes are the ultra-violet rays, while the red rays and those nearest to them have little or no effect. Electric light has hardly any potency in this matter of destroying microbes. As heat which is not sufficiently great to kill a microbe is yet able to make it more or less harmless, so is sunshine. Dr. Palermo of Naples showed that comma bacilli, protected from the sun, killed guinea-pigs in 18 hours as usual, but exposed to sun for 3½ to 4½ hours, they were quite harmless, guinea-pigs inoculated with the bacilli so exposed not developing any kind of disease though it was found that the bacilli were still alive and lived and multiplied as usual. But more than this, the guinea-pigs inoculated with the bacilli thus exposed to sunshine were actually protected from the poison, as after a week these same guinea-pigs were inoculated with the virulent cholera bacilli and they did not succumb.

1,292. Besides heat, air, and sun-light, there are other potent agents for killing or restraining the growth of microbes. Agents which actually kill microbes are called *germicides*, *e.g.*, corrosive sublimate, quicklime, iron and copper sulphates, chlorine gas and carbolic acid. Agents which only restrain the development of microbes without killing them are called *antiseptics*, *e.g.*, salt, sugar, oil, and small quantities of sulphate of iron, etc. Germicidal substances used in a very dilute form act like antisep-

tics. *Disinfectants* is the common name given to germicides and antiseptics. Spores resist the power of disinfectants longer than vegetative forms. Products of germs (toxins etc.) are generally antagonistic to the growth of germs. But the germs themselves are made up of a protoplasmic substance which is highly helpful to the growth of germs. So instead of filtering, if we boil water which is supposed to contain many germs, we prepare only a weak broth in which germs multiply very fast. Between filtering and boiling, filtering should be preferred. But filtered water which is boiled and consumed immediately afterwards is the safest drink. The haphazard direction given by municipalities to drink boiled water when any epidemic is raging, is conducive to more harm than good. Ordinary water after it is boiled soon gets a bad smell due to the ready growth of germs in what is practically a weak soup.

1,293. Some microbes are both parasitic and saprophitic. These are called facultative parasites; *e.g.*, the bacilli of anthrax, cholera and typhoid. Typhoid germs multiply not in cold but in warm water and cholera germs in water containing much organic matter. As a rule, however, putrefactive germs do not grow inside living animal tissues, and parasitic germs in water. The bacilli that abound in the intestines are anærobic and do not grow in the blood until death, when they quickly multiply and help to decompose the corpse.

1,294. Different species of microbes can subsist in the same substance, such as milk, butter etc. Scalding kills the bacillus lactis in milk but it does not kill certain bacilli which have the power of turning milk bitter instead of acid. Under certain conditions these bacilli may multiply and produce bad taste in milk. Weigmann's bitter-milk bacilli are feebly motile and spore-forming bacilli, which sown in sterilized milk give it a very bitter taste, in 24 hours. Cohn's bitter-milk micrococcus has a similar effect on milk. The

same may happen when instead of Bacterium butyricus, other microbes predominate in butter. In all processes of fermentation, *e.g.*, fermentation of indigo, of wine, of cheese &c., it should be seen that the proper microbe has full play, and not another. These proper microbes can be separately cultivated in sterilized bottles of broth, gelatine &c., plugged with sterilized cotton wool. The desired fermentation can be expedited by the addition of these cultures. This is a subject of great economic importance, and the wine manufacturers of Europe are indebted to Pasteur for teaching them the secret of proper brewing of wines and beers. Substances in which microbes have grown when they become dry and powdery get lifted up by currents of air, and dust laden with spores of microbes thus gets disseminated through air. If industrial fermentations, such as fermentation of indigo, wine, butter, cheese etc., have to depend upon the right kinds of microbes dropping into the indigo or wine vat etc., uncertain results are inevitable. Pure cultures of the right kinds of microbe should be added to enhance the right kind of fermentation.

1,295. *Culture-media*.—Meat-broth, a mixture of gelatine and agar-agar, boiled potato, milk, blood-serum, or decoction of plants, is first sterilized at a temperature of 239°F., for a quarter of an hour and then used for cultivation of microbes. Bacteria require for their nourishment albuminoid matter, carbon (which they can derive from the culture-medium) and ash constituents, *i.e.*, K, Na, Ca, Mg, Fe, P, S, and Cl. All these substances being naturally present in milk and in blood-serum, in a soluble and readily assimilable condition, they are excellent natural media for the growth of bacteria. The culture-medium must not be too acid nor alkaline.

1,296. *Mounting of Bacteriological slides*.—When epidemic is feared, or the presence of pathogenic organisms are suspected in milk, butter, blood, or any other fluid or semifluid substance, microscopic examination of the sub-

stance or tissue should be done in the fresh state, and if the suspicion is confirmed, permanent mountings should be made and expert opinion sought in the matter.

1,297. A drop of the fluid or the substance to be mounted is taken up with a clean glass rod or tube, or better still with a bit of sterilised platinum wire, and spread over thin on a number of cover-glasses. These are first air-dried and then passed rapidly through the flame of a spirit lamp or Bunsen burner, taking care that the side of the cover-glass with the film of the substance treated, is on the upper side. The prepared cover-glasses are then put in a dyeing solution for different periods of time,—say, two for 5 minutes, two for 10 minutes, two for one hour, and two for 24 hours.

1,298. A very good *staining solution* to use is the Ziehl-Neelson solution which consists of one part of Fuchsin, ten parts of absolute alcohol and one hundred parts of a five per cent. aqueous solution of Carbolic acid. The Fuchsin is first dissolved in the alcohol and the carbolic acid solution is then added to it. The solution should be kept in a non-actinic stoppered bottle.

1,299. Another good staining solution is Löffler's Alkaline Methylene Blue. This consists of 30 parts (in volume) of a concentrated alcoholic solution of Methylene Blue and 100 parts of a ·01 per cent. solution Caustic potash.

1,300. Gentian violet and Fuchsin Red are the two commonest stains in use. 2 to 5 grammes of either of these aniline dyes are taken and rubbed up in a mortar with 10 C. C. of absolute alcohol, and then gradually 90 C. C. of warm distilled water are added while proceeding with the rubbing. The solution thus made should be kept in a non-actinic stoppered bottle.

1,301. When the film on the cover-glass has been under the dye for a certain period (which is different with different bacteria), the bacteria take the dye. The excess dye on the cover-glass is washed away first with distilled water (with

the help of a wash bottle), and then with a 30 % nitric acid solution if the Ziehl-Neelson solution has been used, or with alcohol and again with distilled water if one of the other stains has been used in excess. After removing the excess dye the cover-glass is again to be dried over the flame, and then with Canada Balsam it is to be fixed on a slide.

1,302. *Counter-staining* is best done by staining the cover glass specimen first in the Ziehl-Neelson solution, and after washing away the excess dye putting a drop of Löffler's Alkaline methylene blue for a minute over the specimen and then washing it out with distilled water, before the cover-glass is finally dried and mounted in Canada Balsam. This method of staining brings out the Tubercle bacilli very prominently, these being coloured red, while pus and other cells and bacteria of other kinds are coloured blue.

1,303. *Decay of food substances* may be prevented in various ways and this is one of the most important applications of bacteriology in the field of agriculture and its allied arts :—

(1) *By dessication.*—This deprives substances of moisture which is necessary for the growth of microbes. Dessication actually kills some microbes, *e.g.*, the cholera microbe. Milk, meat and fruits may be rapidly dessicated and preserved in air-tight tins. The dessication of fruits and vegetables is done by the "Gnom" Evaporators (Waas patent) which are sold at various prices ranging from 30 shillings to £30 by Messrs. L. Lumley & Co. of America Square, Minories, London, E. C. It consists of a series of trays placed one above another in a vertical frame. Underneath is a hot air stove from which a current of hot air, of a temperature of 120° to 180°F. passes up through the series of trays. The process of drying commences at the lowest of the series of trays, where the heat is the greatest. By a lever arrangement the whole series of trays may be lifted up admitting a tray at the bottom. Successive

trays are thus added at the bottom and the upper trays removed. Before the fruits or vegetables are put in, they are peeled, cored, or sliced, as necessary. Carrots and beans, for instance, are sliced, and most fruits are peeled, and vegetables, as a rule, sliced and steamed for a few minutes before they are dessicated. One hundred lbs. of fruits or vegetables are reduced to 10 to 30 lbs., according to the variety treated.

(2) *By freezing* which must be continuous, as freezing does not kill the microbes but only suspends their action so long as the freezing lasts. Meat, fruits, &c., can be transported from one country to another in freezing chambers.

(3) *By addition of harmless antiseptics*, such as sugar, oil, salt, smoke &c. Smoked and salted fish, bacon, preserved fruits jams and jellies, are examples of this. The preservation of lime-juice with powdered charcoal is another example under this head. The addition of 64 grains of borax to every quart of milk can be practised without harm, but it prevents curdling only for about 24 hours.

(4) *Addition of minute quantities of strong germicides* which being poisonous and injurious to human health should not be encouraged. The use of alum for purifying and preserving drinking water, of bicarbonate of soda for preserving cakes of condensed milk, &c., are examples of this.

(5) *Use of Vinegar* and *spirits of wine* for pickling and preserving medicinal substances may be also mentioned in this connection.

(6) *Curries &c.* are now largely preserved in tins in the cooked condition always ready for use. After the cooking has been done, the article to be tinned is put in the tins which have been already washed with boiling water or steam and fumed with sulphur fumes. The tins with their contents are heated twice more (the soldered tins being put in boiling water each time) at intervals of 12 hours before they are finally stored. The first cooking causes those spores that are not killed to germinate afterwards, and the first

heating kills the germinated spores, while it helps others that may not have germinated already, to germinate and get killed at the second heating.

(7). *Sterilizing of milk* is an adaptation of the same principle. As milk is altered in character by boiling, and as even boiling temperature continued for an hour or two may not kill all germs, it is very difficult to preserve milk in an unthickened condition. The method employed by Tyndall is tedious. It consists in heating the milk on eight consecutive days, for two hours each day, at a temperature of 65° C, and keeping the milk in the intervening periods at the temperature most suitable for the growth of bacteria, *viz.*, the temperature of 40° C. The value of the milk is not affected by this treatment and it continues to remain fresh. Stoves for keeping a certain space at a uniform temperature for any length of time, such as Etuve Pasteur, are necessary for preserving unthickened milk for a long time in fresh condition.

(8). The *condensed milk* prepared by sterilizing in vacuum pans without the addition of sugar, such as is done in the manufactory of Drenckhan, in Stendorf, near Eutin, Switzerland, has proved the best substitute for fresh milk. The gravity of this thickened milk at 15°C is 1·1 and its composition is :—Water—66·2 per cent ; Fat—8·4 per cent. ; Nitrogenous matter—10·9 per cent. ; Milk-sugar—12·3 per cent. ; Ash—2·2 per cent., while that of ordinary fresh milk the composition is--

Water	87·5
Fat	3·6
Nitrogenous matter	3·3
Milk-sugar	4·9
Ash	·7
	100·0

This Sterilized condensed milk is obtained by purifying

the fresh milk by applying to it centrifugal force, and afterwards boiling it to coagulate the albumen and reducing it to a third or fourth of its original volume. It is then poured into metal vessels which are filled and then soldered and then placed at a temperature of 120° C for two hours. The keeping quality of the milk is then proved by storing it in a temperature of nearly 40° C for a few weeks, after which if the top or the bottom of the vessel distends, it is inferred that gases due to putrefaction have generated inside the vessel, and any vessel showing such distention is rejected.

(9). *Pasteurised milk.*—By Pasteurising is meant destroying *vegetative microbes* by continuous heating for a quarter of an hour at a temperature of 75° C, and then sealing up the glass flask containing the milk. This operation makes milk practically safe for use, as the microbes of tuberculosis, typhus and cholera, have no persistent spores capable of resisting great heat, and the milk keeps longer, say for 24 hours,—after it has been pasteurised. Pasteurised milk is only temporarily sterilized milk. The safest thing to use, however, is perfectly sterilized milk, or sterilized condensed milk.

CHAPTER CXXVII.

DAIRY BACTERIOLOGY.

HAVING given a general notion regarding the utility of a knowledge of bacteriology, we will now go on with the consideration of certain special microbes with which agriculturists are concerned. Ordinary fresh milk may contain as many as 50 million microbes per pint without looking or tasting any the worse for it. But if the cows and the cowhouse are kept scrupulously clean and if the person milking washes his

hands and the pail properly, there are much fewer microbes. The last strippings of milk are free from microbes.

1,305. The Bacillus lactis converts milk-sugar into lactic acid. As this ferment is the agent for curdling milk into *dahi*, and as *dahis* are apt to get more or less improperly curdled, the conditions required for the most perfect curdling of *dahi* should be understood. The *sánjo i. e.* the seed or culture, should be made of skim-milk and not rich milk, as it is not desirable to associate the butyric ferments with the lactic. The skim-milk should be taken in the fresh state, heated to about 75° C to pasteurise it, *i. e.*, to temporarily kill all the germs and then, after adding a little watery portion of any *dahi*, to leave the pasteurised and inoculated skim-milk in a cool place, *i.e.*, at a temperature of about 16°C. This can be used afterwards as souring agent for making good *dahi* or for souring cream before churning it into butter. We often find *dahi* of a slimy character. This is due to a micrococcus attacking the milk-sugar in larger numbers and replacing or resisting the action of the lactic bacilli. This micrococcus multiplying becomes a zooglœa, and the slime is a zooglœa-slime. There are other characteristics we notice in *dahi*, the most noticeable of which are coloured patches on the surface of pots of *bazaar dahi*. The blue patches are due to Bacillus cyanogenus, the yellow patches to Bacillus synxanthus; and the blood-red patches to Micrococcus prodigiosus. There is a Sarcina which produces rose and another which produces brown-red, colour, and Bacteria lactis erythrogenes while coagulating milk like Bacillus acidi lactis imparts to it a blood-red colour if light be excluded. These *chromogenic* microbes which are fairly common in milk, are not known to produce disease, though the blood-red colouration produces a superstitious horror which induces owners of valuable cows to part with them at once, as they do not know the cause of the blood-red colouration was not present in the cow at all, but in impuri-

ties with which the milk came subsequently in contact. Redness of milk due to the mixture of blood from inflamed udder is a different thing altogether, where the redness is visible at the time of milking.

1,306. There is not one bacillus only which curdles milk and causes milk-sugar to split up into lactic acid and carbon-dioxide gas. The curdling itself could be caused by any acid, as in the preparation of *chhánā* out of boiled milk, and also by certain enzymes, *e.g.*, rennet, and the milk of *sheorá*. The principal bacteria causing curdling are : (1) The bacillus lactis of Hueppe which is a thick short rod growing best at temperatures varying from 50° to 113°F, the optimum temperature being 95°F. This is the bacillus that produces the most uniform *dahi* which does not liquify readily as some *dahis* do. (2) The bacillus lactis of Grotenfelt produces alcohol as well as lactic acid and carbondioxide gas. (3) Bacterium acidi lactici, (4) Micrococcus lactis I and II of Heuppe, (5) Micrococcus acidi lactici, (6) Sphærococcus acidi lactici, (7) Bacterium limbatum acidi lactici, (8) Micrococcus acidi lactici of Krueger, and (9) Streptococcus acidi lactici of Grotenfelt, are other microbes also which produce lactic fermentation in milk. As none of these are known to develop spores, they do not require very much heat to kill them. A temperature of 158°F is sufficient to kill them and then a pure culture of bacillus lactis of Hueppe may be used for obtaining first class *dahi* and first class butter, such as are ordinarily obtained by some *gowálás* in some districts.

1,307. When *dahi* is kept too long, a visible mould develops on the crust. This is the Oidium lactis, which is a higher fungus consisting of hyphæ and spores.

1,308. Sliminess and stringiness of *dahi* are caused by various fungi many of which have been studied.

1,309. *Cheese.*—Besides the lactic ferments there are the cheese or casein ferments which break down the casein of milk. These ferments being mostly spore forming ferments

are difficult to kill in the milk and these account for the difficulty in sterilizing milk. The commonest of these is the Tyrothrix tenuis of Duclaux. It can stand a temperature of 239° to 248° F. Cultivated in milk at a temperature of 98½°F it is capable of curdling milk, the curdles formed being redissolved afterwards by the action of the same bacillus. The decompositions effected by this bacillus result in the production of peptone, leucin, tyrosin, ammonia, butyric acid &c. Other bacteria also play a part in caseous fermentation, and probably still others in the ripening of cheese. It has been noticed that cheese does not ripen properly if the milk is pasteurised, or if boiled or sterilized milk is used before the addition of rennet. Such milk loses most of the bacteria some of which are helpful in the ripening of cheeses. But the bacteria helpful in the ripening of cheeses have not been isolated, and no improvement in the ripening of cheese, due to the addition of pure cultures of specific bacteria, has been as yet effected. Besides it is doubtful whether there are any specific bacteria which help in the ripening of cheeses, or whether the lactic and the caseous bacteria are not helpful to the ripening also.

1,310. *Kephir.*—There is a Saccharomyces (S. lactis) which is able to convert milk-sugar into alcohol and carbonic acid gas, and very little lactic acid. Kephir is the name of a fermented beverage made out of cow's milk by the addition of what is known as 'Kephir grains' which consist of fungi which include the Saccharomyces lactis, also a gelatinous filamentous Bacterium known as Dispora caucasica and the commonest bacterium of lactic acid. One volume of the grains are added to 7 volumes of fresh milk and the mixture exposed to air for 24 hours, protected from dust by the loose covering of a cloth, and shaken from time to time. The milk is then strained off from the grain and is mixed up with twice the quantity of fresh milk, bottled, corked and stirred from time to time. This is drunk in 2 or 3

days. The proportion of alcohol generated is 1 to 2 per cent.

1,311. *Butter*.—Though some of the caseous bacilli are classed as butyric, it is not to be supposed, that butter is a product of fermentation. Butter can be made from fresh milk as well as from sour *i. e.*, fermented milk. Butter made from sour milk or sour cream, keeps better, and by souring a larger proportion of butter is obtained. Butyric acid, no doubt, is obtained as a residue from the breaking down of milk-sugar which is effected by various lactic ferments ($C_6H_{12}O_6 = C_4H_8O_2 + 2CO_2 + H_4$). The presence of butyric acid can be detected in all ripened cheeses. As the fat globules of milk come together more readily if their caseous envelopes are decomposed by fermentation, caseous fermentation also plays a part in most of the ordinary processes of manufacture of butter. If butter is made from cream, milk should be used in as fresh a state as possible, and if no centrifugal separator is employed the milk should be set in shallow pans, fermentation being prevented by rendering the milk as cold as possible by rapidly passing the fresh milk through a refrigerator, that the milk may be set at a temperature of 12 to 15° C (say, 55°F). If fermentation sets in, coagulation takes place which offers resistance to fat globules rising readily to the surface. After the fat globules have come to the surface, the top portion of the milk is skimmed off. This, containing all the fat globules is called the cream, and from this butter should be made after fermentation, or fresh milk can be fermented and butter made from the fermented sour milk or *dahi*. In this climate it is difficult to secure the proper temperature for setting of cream, and it is better therefore to obtain butter from *dahi* or from clotted cream (*shar*) as is the general practice of the country. The latter method is practised in Devonshire also where the milk is set in deep tinned vessels, or pans of iron or of brass, and after 12 hours' standing without disturbing them, fire is lit and

the milk heated till the first steam is seen in bubbles on the surface of the milk, after which they stand still undisturbed on the cold oven, till the milk is quite cool, and then (say after 10 or 12 hours) the cream is skimmed off. The cream so obtained is left to ferment before butter is churned out of it, which is usually done by flapping it with the hand in a tub for about 10 minutes only. This modified plan of making butter out of *shar* may be introduced in this country. Churning should be done early in the morning. But if the temperature at this time be below 64°F, sprinkling of warm water while churning *dahi* or *shar* helps to bring the fat globules together faster. All the fermentation and other processes applied in the manufacture of butter, help only to bring the fat globules already existing in the milk to come together in as pure a state as possible, divested of all sugar and casein. If the quantity and the keeping quality are of no consideration, the sweetest butter can be obtained out of the freshest milk, by separating the cream out of it and churning the cream in the fresh state. The milk also can be churned directly to yield some butter, though a less quantity still is obtained by this means.

CHAPTER CXXVIII.

SOIL BACTERIOLOGY.

IT has been known, that land left without crop increases in fertility in spite of loss of soluble matter by drainage. It has been further observed, that poor soils which yield very poor returns of cereals, turnips, and beet, are yet capable of yielding good returns of leguminous crops; and further, that land

which has got deteriorated by heavy cropping is recuperated by growing on it a crop of clover, *arahar,* or some other leguminous crop. The power of fungi to make use of the free nitrogen of the air has been demonstrated by various observers. Probably Ammonium nitrite is formed first ($N_2 + 2H_2O = NH_4 NO_2$) and afterwards the more complex organic compounds, which ultimately go to form the protoplasmic matter of which the fungi are composed. The multiplication of the fungi (bacteria) at the root-nodules of leguminous plants has been chiefly studied. Hellriegel was the first to point out that the root-nodules in different plants are caused by different microbes. It is now also known that the root-nodules are not confined to the leguminosæ, and probably bacteria have a wide influence in feeding plants with nitrates. But it is only the bacteria that cause root-nodules that have a marked effect in enriching the soil, though some nitrogen is accumulated in the soil by all fungi whether they live on roots or not. Berthelot's experiments went to show that 75 to 100 lbs. and in some cases over 900 lbs. of nitrogen per acre was accumulated by Bacteria and that humus rather hindered than helped accumulation of nitrogen from this source. Fixation of nitrogen in the soil goes on by day and by night, but more actively in day time, and in high temperatures (50 to 104° F), though all nitrification due to Bacteria ceases at 230° F. Free access of air, and moisture from 12 to 15 per cent., are also most helpful. Though nitrifying Bacteria accumulate largely in the roots of leguminous plants, soils in which leguminous crops have recently grown are not helpful to nitrification, thus there is a limit to the accumulation of nitrogen by the growth of leguminous crops, and it is not possible to go on increasing the fertility of soils by taking one leguminous crop after another. Rotation therefore is necessary. It is not possible to go on increasing the quantity of microbes in a given quantity of any culture-medium and soil is no exception to the rule. Even manures by keeping

and fermenting gain in value up to a certain point, after which oxidation actually diminishes their value. Fermenting in manure heaps should proceed only for about 4 months after which the manure will rather lose than gain in value, and as for urine the fresher it is used the more valuable it is as manure, as the fermentation, caused by micrococcus ureæ converts the urea into Ammonium carbonate which is highly volatile. To prevent fermentation, urine is kept in vats for some time before use, if it is necessary to do so, by mixing with it an antiseptic substance, such as sulphate of iron.

1,313. Though the uppermost layers of soils teem with microbes, there are scarcely any microbes below a depth of 3 feet from the surface. Nitrification going on more freely at the surface, nitrebeds are made only with the superficial layers of soil and not with soil dug out from a deep pit. It is not certain if the nitrification which results in the formation of saltpetre is the result chiefly of the action of one microbe or the joint result of that of several microbes. Van Tieghem regards Micrococcus nitrificans which is a very small and delicate micrococcus, as the determining agent, while Duclaux attributes the result to the joint action of several microbes. Another microbe which has a wide influence in decomposing decayed vegetable matter by destroying the cellulose of vegetable cells is the Bacillus Amylobacter of Van Tieghen. It is a drum-stick shaped anærobic microbe and is the active agent in the retting of jute &c. Probably nutrition of ruminant animals which are able to digest a large proportion of cellulose, is partly due to this microbe. This microbe is also one of the active agents in the production of butyric acid in cheese, hay, silage &c. The commonest microbe of putrefying vegetable matter is the Bacterium Termo. It can be always obtained by rotting some pulse in water; while rotting hay shows Bacillus subtilis more abundantly. Bacillus subtilis, Bacterium Termo, Bacterium Amylobacter and Micrococcus-

Ureæ, are the commonest of all microbes and are present everywhere.

1,314. *Root nodules and Nitragin.*—Nitragin is a substance made in Germany and protected by letters patent. It consists of a jelly on which there has been sown minute organisms derived from the little warty growths or nodules, such as are found in the roots of leguminous plants such as *arahar*, *dhaincha*, *sunn*, ground-nut &c. It is manufactured and sold by a chemical firm Meister, Lucius and Bruning, Höehst-am-Main, Germany in little bottles containing an ounce or two of jelly, on the surface of which a white mould looking substance has been grown. It is claimed by the manufacturers that this small speck of white fungus, if mixed with about half a gallon of water, and the water sprinkled carefully over about a cwt. of earth, and thoroughly mixed with it, is capable of inoculating half an acre of land when spread over it as a top-dressing, and that land so inoculated will in most cases produce a much larger crop of clover, peas, beans, or other leguminous plants, than uninoculated land.

1,315. The root nodules of leguminous plants were first discovered by the famous anatomist Malpighi about the year 1660. For two centuries no further notice was taken of them until a Russian botanist Woronin made a careful microscopic study of them. He described the root nodules in 1866 and noticed that at a certain stage of their development they were filled with a slimy matter containing myriads of tiny little bright corpuscles capable of motion and resembling bacteria, and he thought they were allied to Plasmodiphora which caused the finger and toe in turnips. Professor Marshall Ward classed the fungus as belonging to the genus ustilago (smut in wheat being caused by a ustilago). De Fries in 1877 discovered that they were absorbers of N, as he found they were full of albumen during the whole life of the plant until about the time of the ripening of the seed in the host plant in which is stored the albumen for the use of the future generation.

1,316. It was Beyerinck of Delft who first discovered that the growth of the nodules was due to a real Bacterium and he grew it in a nutrient medium outside the plant taking his seed from a variety of leguminous plants. He gave the Bacterium the name of Bacillus Radicicola.

1,317. Hellriegel first discovered that the nodules enabled leguminous plants to make use of the free N. of the air by converting it into living organic albuminoid matter in their bodies. Experiments made by Boussingault in France and repeated by Lawes and Gilbert in England, confirmed this point once for all.

1,318. The manufacture of Nitragin was the result of the experiments conducted by Professor Noble of Tharand in growing pure cultures of Bacillus radicicola in gelatine to which was added, when liquified, a decoction of the plant on which the organism under investigation is accustomed to feed. Noble found that the best results in the way of inoculation were attained when the micro-organisms were got from a soil growing plants of the same kind as those he was experimenting with, so that in order to give vigour to a clover crop, the soil should be inoculated with micro-organisms obtained by cultivation from the nodules of the clover plant, and so on. Thus the Bacillus radicicola of Beyerinck, though it was recognised by Noble as the one original organism present in all soils, is powerfully affected in its nature by the nature of the leguminous plant it grows on. Accordingly in preparing material for inoculation, cultures made from the nodules of the various species of leguminous plants are kept distinct, so that they may be used for application to crops of the same species only.

1,319. The credit of cultivating Bacillus radicicola in a pure state and of a kind best suited to each species of leguminous plant, is due to Noble and Hiltner of Tharand from whose hands the manufacture has now passed into the hands of a Chemical Manufacturing Company who charge

3 shillings per bottle of Nitragin, a quantity sufficient to inoculate half an acre to an acre of land. The substance should be used within a month after it is sent out from Germany mixed up with earth and so diluted for even distribution. Experiments conducted in Scotland, however, have shown that Nitragin is not any more effective when used new than when it is used after several months. Dr. Aitken of Edinburgh regards Nitragin as useless for all practical purposes, as none of the Scotch experiments showed any decisive result in its favour.

CHAPTER CXXIX.

ANTHRAX AND OTHER VACCINES.

ANTHRAX and Charbon.—There are two diseases, entirely different in their origin and manifestations, known as *Charbon.* In fact, the name *Charbon* originated from the black-red colour of the muscle which is a characteristic symptom of *Charbon-symptomatique*, (*galá phulá*) but not of the *Charbon virulent* or anthrax (*go-basanta* or *guti*). Anthrax should not be called charbon at all, and the synonym, splenic apoplexy is perhaps more appropriate, although one of the characters which distinguishes anthrax from charbon symptomatique is, that whereas in the latter disease the affection is localized, in the former it is systemic, although the spleen contains the largest number of the organisms of the disease in the case of anthrax. The Indian name, Ludhiana fever, expresses the systemic character of the disease, but it is also vague. The Bengali names *guti* and *go-basanta* are most misleading as the external lesions or *guti* appear only in a very small proportion of cases, and these generally do not prove fatal. In

the absence of better terms, we shall call the charbon symptomatique of the French, simply charbon, and the charbon virulent of the French, anthrax, to avoid confusion.

1,321. Inoculation for protecting animals against disease is done for both anthrax and charbon. The vaccines for anthrax are prepared in different ways by different persons. M. Pasteur's vaccine, however, is the one which is more extensively used than any other, and the preparation of this will be fully described. A description of two more recent methods, *viz.*, those of M. Chauveau, formerly Director of the Veterinary College at Lyons, also applied in preparing anthrax vaccine, will, however, be found both interesting and useful, especially on account of their simplicity. M. Arloing, the present Director, believes they are equally as effective as Pasteur's method.

1,322. The vaccine for charbon was first prepared by M. Arloing. His system is now adopted in practice, and the vaccine is sold by MM. Marais et Fromage, droguistes, Rue Lebrim, à Paris.

1,323. The *characters that distinguish* anthrax from charbon are :—

(1). Anthrax is fatal to almost all animals known. Charbon virus, if inoculated into horses, mules, rabbits, or dogs, does not have any effect. White mice may or may not die of charbon when inoculated with the virus. The animals most susceptible to charbon are cattle. Cows and oxen *die* more frequently of charbon than of anthrax from which about half the number recover. Sheep and guinea-pigs are also susceptible animals, that is invariably die when inoculated with the virus, whether of charbon or of anthrax. The subject has not yet been sufficiently investigated to enable one to say whether man is more subject to one than to the other. Limping before death is an invariable symptom in charbon.

(2). Œdema takes place at the point of inoculation in both anthrax and charbon. When an incision is made of the

œdematous part, the appearance which presents itself in the case of anthrax is moist, bright and gelatinous, and light red. In the case of charbon, however, the œdematous part on incision presents a dull dark red, almost black, appearance. The œdematous part in the case of anthrax also is redder than in the natural state ; but the difference in colour in the two diseases is most characteristic.

(3). Both charbon and anthrax are virulent for susceptible animals ; but charbon is quicker in its effect, death taking place within 24 hours ; whereas, in the case of anthrax, oftener after 36 hours, and usually, if the animal lingers for more than a week, recovery takes place. Two guinea-pigs inoculated at the same time by M. Arloing, for demonstrating the difference between the two diseases, were found two days afterwards, one dead and ready dissected, and the other (*viz.*, that inoculated with anthrax virus) still alive.

(4). The disease in the one case is caused by a non-motile bacillus, *viz.*, in the case of anthrax, and in the other, *i. e.*, in the case of charbon, by a bacterium, which is a shorter organism, which never forms chains as bacilli do.

(5). The organisms of disease are found in the case of anthrax all over the body, more or less in every tissue, but more particularly in the spleen, the heart, and the liver. In the case of charbon they are found only in the œdematous part, and they are invariably localized.

(6). Swelling of the glands of the neck is invariably present in the case of charbon when it arises spontaneously, and only sometimes in the case of anthrax. So neck swelling must not be regarded as the diagnostic symptom in the case of gloss-anthrax or charbon.

(7). A crepitating sound of the œdematous part is always present in the case of charbon, never in the case of anthrax.

(8). Spores are formed in the charbon organism (named by M. Arloing, Bacterium Chauveau) in the body of the animal

even when it is still alive. In the case of anthrax, the spore formation of bacillus anthracis goes on *only* outside the body of the animal, when the bacilli come in contact with the free oxygen of the atmosphere.

(9). Bacillus anthracis is a longer but narrower organism than Bacterium Chauveau. In artificial culture, Bacillus anthracis appears as long filaments; whereas, under similar conditions, Bacterium Chauveau appears even shorter than in its natural state, the reason being that this bacterium is an anærobic organism, incapable of full development in contact with free oxygen of the air.

(10). Bacterium Chauveau is rounded at the ends, Bacillus anthracis, straight; Bacterium Chauveau in decaying becomes more inflated; but in a dry state, narrower (as in the vaccine).

(11). Bacterium Chauveau is never found in chains of three or more, like bacillus anthracis. The usual mode of vegetation is by spore formation, sometimes, however, section or gemmation takes place, but never in a series of more than two.

(12). An animal dying of anthrax is almost invariably found bleeding from the anus and nostrils. An animal dying of charbon has never this symptom.

1,324. The black colour of muscles in charbon is caused by the extravasation of blood into the muscular tissues, caused by the solving action of the diastase of the Bacterium Chauveau dissolving the muscular cells and allowing blood to flow into them. Greater oxygenation goes on, the bœmoglobin of the blood losing more oxygen than in the natural state, and the CO_2 gas produced helping the further development of the anærobic bacteria. The light red arterial blood becomes exaggeratedly veinous and dark, in consequence of this action.

1,325. The above information regarding anthrax compiled by the author while working at Pasteur's Laboratory in Paris, may be supplemented by quotations from a paper entitled

"Anthrax and Anthracoid Diseases" by Principal Williams of the New Veterinary College, Edinburgh, which appeared in the Transactions of the Highland and Agricultural Society of Scotland for 1888:—

"*Definition.*—The disease consists in a special and primitive alteration in the blood, in which an organism termed the Bacillus anthracis is rapidly developed and propagated, and is more special to the herbivora and birds. Inoculation with the blood or tissue of animals which have died from it induces, both in man and other animals, a malignant form of inflammation called malignant pustule. For this reason anthrax is looked upon, and described, as a truly contagious disease.

"Observers who have closely watched these affections in this country, where it seldom appears in the horse, almost unanimously conclude that in cattle and sheep they are due to dietetic errors; more particularly to sudden and violent changes in diet, whether that change be from a poor to a highly nutritious, more particularly a nitrogenous diet; from dry and good food, to watery, unripe provender, to damaged food of any kind; the influence of undrained lands; defective ventilation and drainage of stables; to food and water contaminated with the morbid product of animals which have died of blood disease.....Anthrax is also disseminated through the agency of flies .....The flies, however, resist the influence of the virus although bacteridæ are found in them.

....

"The bacilli are not always found in the blood of living animals suffering from the disease; indeed, they generally appear a few hours before death (which seldom takes place in less than twenty hours), and then only singly and in very small numbers. Even after death they cannot always be found in the blood, but always in the spleen.

....

"The experiments of Bert, support to some extent the conclusions of Pasteur. In a series of experiments Bert submitted anthrax blood to the action of considerably compressed oxygen, and found the bacilli had disappeared, killed by the oxygen, and yet the blood retained its virulence, for it killed rabbits, guinea-pigs and dogs, inoculated with it: and in another series of experiments Bert took anthrax blood containing bacilli and added drop by drop of absolute alcohol to it, until a precipitate was formed, which was dried in vacuum. The dried powder was injected under the skin, and it killed a rabbit, a guinea-pig and even a dog.

....

"It has been stated that the bacilli destroy life—(1) by acting as asphyxiants, depriving the blood of its oxygen; and (2) by mechanically obstructing the blood-vessels. Against both these theories must be placed the fact that they are very few in number, indeed *often absent altogether in the blood during life.*

"Anthrax is not transmitted by infection from one animal to another, for animals kept in the closest proximity to diseased ones, and placed under the most favourable conditions for infection through the air, do not become diseased.

"Anthrax in the horse rarely occurs in this country, but is prevalent in India, where it is said to attack the elephant as well as other animals. ....

....

"The symptoms in the ox are very analogous to those in the horse. The ox suddenly goes off its feed; rumination is suspended; there are rigors and tremblings; partial sweats bedew the body, which is alternately hot and cold. The dorso-lumbar region is excessively tender to pressure, and when it is the seat of the tumour, very acute pain is thus caused; the gait becomes staggering, and the animal rapidly exhausted. A recumbent posture is almost constantly maintained; the animal will now and then attempt to rise, but

will rarely succeed in doing so. When standing the back is arched, the legs stiff and rigid, but the standing posture is not long maintained. The animal looks towards its flank, falls into convulsions, and expels without much effort *soft and bloody matter by the anus*.....The respiration is panting and plaintive, there is tympanitis of the abdomen ; the tongue is bluish red, and the mouth filled with mucus ; *blood escapes from the nose* ; the eyes are sunk in their orbits, and tears flow over the cheeks. The areolar tissue of the back and sides becomes crepitous to the touch, and the animal dies during a convulsive exacerbation, or during the succeeding calmness. In some animals the excitement is so great it is dangerous to go near them. The rapidity with which the symptoms succeed each other is variable, death taking place in the space of from a few minutes to twenty hours.

"In cattle above two years old, particularly milch cows, the local lesions are often confined to great congestion of the spleen, and to a lesser extent of the liver and mucous membrane of the intestinal canal. In other, but rarer instances, the engorgement may be in the lungs, and should the animal survive for some days, decomposition of the extravasated blood is established, as expressed by fœtor of the breath ; the decomposed extravasated blood being absorbed into the circulation, causing death by septicæmia.

....

"If, however, the disease is not so rapid in its course, it may be noticed that there are various alterations in the symptoms ; in some instances an animal will be unwell for several days, suffering from a remittent fever ; one day very ill, with rapid, feeble pulse, hurried and painful breathing, red and injected eyes, hot mouth, irregularity of the bowels, and redness of the urine. After continuing for some hours these symptoms may subside, and the animal commence to eat and ruminate. The febrile symptoms, however, often return, and in the end the sufferer too often succumbs.

"In another form of anthrax without external tumours, the most prominent sign, in addition to the general disturbance, is the passage from the bowels of quantities of dark-coloured blood; and the disease is then denominated *enteric* or *abdominal charbon*, the *post-mortem* characteristics being congestion of the intestinal mucous membrane, more particularly of the *small intestines*, which *are covered with petechial spots*, with incipient ulceration in their centres, extravasation of dark-coloured blood into the canal."

After studying the subject of Anthrax at Pasteur's Laboratory in Paris, and observing the external symptoms of animals affected with what is called in this country rinderpest, *gobasanta*, *guti*, or *Mátá*, the author of this Handbook was so convinced that the commonest cattle-plague of India was anthrax, that he proceeded with the post-mortem examination of the organs of affected animals and the microscopic study of the blood, and he was confirmed in the belief that rinderpest was anthrax pure or simple, all the four forms occurring indifferently in a herd of affected animals, *viz.*, (1) the systemic or febrile form often ending in symptoms which are mistaken for those of rabies; (2) the dysenteric or abdominal form which is the commonest form; (3) the form with external lesions, cases of this generally recovering and proving immune ever-afterwards, though sometimes sores and other secondary symptoms supervening some cases prove fatal, and (4) the form with swelling of the neck (but without any crepitating sound) which may be mistaken for gloss-anthrax. True, the only diagnostic symptom of anthrax is the presence of Bacillus anthracis, and in every case in which the author has examined the blood of an animal said to have died of Rinderpest, he has observed the Bacilli; though in the blood from the anus of animals still suffering, or from the blood of affected animals killed for the purpose of examination, the B. anthracis could rarely be found. If, however, the quotations from Principal Williams',

paper are carefully considered, it would seem that we could not expect to see any Bacillus anthracis in such cases.

1,326. *Principle of Inoculation.*—Pathogenic or disease producing organisms subjected to certain conditions, either diminish or augment in their virulence. The virus of swine plague inoculated in pigeons increases in virulence at each successive generation of its passage through pigeons. If, however, this virus is passed through successive generations in the bodies of rabbits, it becomes gradually attenuated in virulence, and after the tenth generation the virus taken from the rabbit may be used for inoculating pigs to protect them against swine-plague.

1,327. Similarly the virus of rabies passing through the bodies of monkeys becomes sufficiently attenuated after the tenth generation for the virus from the tenth monkey being used for inoculating dogs to protect them from rabies. Passing, however, through the bodies of rabbits, the virus of rabies augments in virulence. A rabbit inoculated with the virus of rabies from a mad dog dies in 18 to 20 days. A second rabbit inoculated with the virus taken from this dead rabbit will take less time to die, and so on, until the 30th rabbit inoculated with the virus from the 29th rabbit takes only six days to die. Here, however, the maximum of virulence is reached; the 31st, 32nd, 33rd, &c., do not die any quicker than the 30th rabbit, but they all take after the 30th rabbit six days to die.

1,328. But the conditions under which pathogenic organisms change their character are various. Some of these have been discovered, and they are made use of in attenuating the virulence of the virus, and introducing the attenuated virus into the bodies of the animals to protect them from accidental inoculation or infection with the virulent virus. The usual methods adopted are heat and drying. Heat is applied in attenuating anthrax vaccine, heat and desiccation both in attenuating charbon vaccine, and desiccation in attenuating

rabies vaccine. It may be interesting to describe the last, *viz.*, the preparation of the rabies vaccine in full, as not only man but cattle also are subject to rabies.

1,329. *Preparation of Rabies Vaccine.*—It has been already stated that successive generations of rabies virus passing through rabbits increase in virulence. The rabbit inoculated (in the brain) with the virus taken directly from a mad dog dies in about 18 days. A second rabbit inoculated with the virus taken from the first rabbit so dying dies in a shorter time. The rapidity with which death follows continues to increase at each successive generation until the 30th. The 31st rabbit inoculated with the virus from the 30th dies like the 30th in six days, and so the 32nd, the 33rd, and so on. The maximum of the virulence of the rabies virus is thus attained in the 30th generation of its passage in the bodies of rabbits. This is the standard virulent virus used by Pasteur in his preparation of the vaccine, as the strength of the virulence is from this stage onwards constant.

1,330. In the case of the human subject (bitten by a mad dog), ten graduated inoculations are made, beginning with the weakest or the most attenuated forms, which do not kill rabbits, and ending with stronger vaccines which are sufficient to kill rabbits.

1,331. The vaccine, like the virulent virus of rabies passing through successive generations in the bodies of rabbits, also increases in virulence.

1,332. To keep a perpetual supply of vaccine a rabbit is inoculated every Saturday in Pasteur's laboratory with the standard virus of maximum strength, the standard attained after the death of the 30th rabbit. Rabbits are used instead of monkeys in the preparation of this as well as other vaccines, as the former are inoffensive animals. It is risky having to do constantly with mad dogs and monkeys. Although the first rabbit is inoculated with virus taken from a mad dog, it is quite unnecessary to have anything else to do with mad

dogs in keeping up a constant supply of vaccine, which is easily done by killing one rabbit every week by inoculating it with virus of maximum strength. The rabbit so inoculated on Saturday dies in Pasteur's laboratory on the following Friday, and on the next day (Saturday) another rabbit is inoculated with the virus taken from the dead rabbit. This also, in its turn, dies on the following Friday, and a third rabbit is inoculated on the third Saturday, and so on perpetually. The standard virulent virus so obtained every Saturday is employed in preparing the vaccine.

1,333. The dead rabbit is dissected, its spinal marrow taken out, and hung inside a glass jar containing potash at the bottom, the jar being placed in a room regulated at a constant temperature of 20° C. The spinal cord thus gets drier and drier, the potash preventing putrefaction, and in drying up it gets more and more attenuated. But even after seven days of desiccation it is capable of killing rabbits. On the 8th day it is harmless for rabbits, and probably much more so for men. But to be more careful the first vaccination applied to man is made with the spinal cord desiccated for 12 days; the second vaccination with what has been desiccated for 11 days; the third with what has been desiccated for 10 days, the 4th with what has been desiccated for nine days; the 5th for eight days; the 6th with what has been desiccated for seven days (capable of killing rabbits unprotected by previous inoculation with weaker vaccine); the 7th (still stronger) with what has been desiccated for six days; the 8th for five days; the 9th for four days; the 10th and the last vaccination with the vaccine prepared from spinal marrow which has remained only for three days in the glass jar. Pasteur stops here. He never vaccinates men with the vaccine which is quite virulent. But he believes men vaccinated 10 times with the graduated vaccines can be inoculated with perfect safety with the virulent vaccines, that is, those made with two and one day's desiccated spinal marrow,

and with undesiccated marrow freshly taken out of the dead rabbit, or the dead dog.

1,334. The desiccated spinal cords are mixed up severally with water in glasses before syringing the vaccines to men. The inoculation is done with a Pravaz syringe, under the abdominal cuticle in the case of the human subject, and into the brain of lower animals for experimental purposes.

1,335. It may be that Pasteur's method of inoculation for rabies, both as a curative and also as a protective measure, will be in future adopted not only in human pathology, but in the pathology of our domestic animals also, which are no less subject to rabies than men.

1,336. *Pathological explanation uncertain.*—Why this method of treatment for infectious diseases (*i.e.*, those caused by lower organisms) should prove efficacious is difficult to say. But analogy goes to show that it is a most natural method. A person may accustom himself to taking gradually larger and larger doses of arsenic until he can take such a quantity without serious harm as would certainly kill one not so accustomed. So with alcoholic poison, opium, and perhaps all poisons. It is like a person accustoming himself to lifting heavier and heavier weights, touching hot substances or performing acrobatic feats. There is an almost unlimited degree of tendency in animal organisms to adapt themselves to the circumstances to which they are subjected if they are gradually subjected to them. This tendency is shared alike by the muscles, the nerves, the viscera, and, in fact, by all living portions of the body. But exactly in what way custom is a protection against susceptibility no one can say. It may be that the particular tissues undergo a chemical alteration in this process of accustoming, and the chemically altered tissues are no longer acted upon injuriously by the otherwise poisonous or deleterious conditions. Inoculation for infectious diseases is a kind of accustoming. It is done in the case of rabies at several stages ; in the case of charbon at two ; in

the case of anthrax, according to Pasteur's method, also at two, and according to Chauveau's methods only at one stage. When the tissues come in contact with the vaccines some chemical alteration probably goes on not sufficient to cause death, but producing œdema or fever, or some slight disease. But the animals getting over this slight disease evidently acquire a new constitution, in which the tissues become invincible to the attack of the violent virus also.

1,337. *Preparation of Vaccines for Charbon.*—An animal dying of charbon can be easily distinguished from one dying of anthrax from the various tests mentioned at the beginning of this Chapter.

1,338. The muscles of the specially affected portion are cut out, triturated well in an ordinary mortar, and the juice squeezed out. The juice so squeezed out is put in a shallow plate to allow of its getting dry before putrefaction sets in. Putrefaction means generation of other organisms, which may displace the organisms of charbon altogether if allowed to go on. When the juice is completely dry, it is scraped out with a knife, pounded into dust, and stored in a dry bottle and in a dry place. The organisms retain their vitality in this dry condition for over two years. When a little of this dust is taken within two years, mixed up with water, and syringed into a guinea-pig, or a cow, or sheep, the animal dies in 24 hours of charbon, with all the characteristic symptoms.

1339 It is this dry virulent dust that is used in preparing the two vaccines, the premier and the deuxième, for applying the two successive injections to animals to protect them against the disease in the districts where it is prevalent. In the Swiss pastures it is very prevalent. In Algeria it is also prevalent, but it does not invariably end fatally as in Europe. In Bengal, cultivators recognise it as a more fatal disease than *go-basanta*.

1,340. The virulent powder is first rendered into very fine dust before it is mixed with water. The mixture is made with

three grammes of the dust to every six grammes of water. This mixture is placed in shallow porcelain capsules, each capsule containing three grammes of the virulent dust and six grammes of water. These capsules are placed inside an étuve Arsonval, only four capsules being placed in one étuve, lest the evaporated moisture should lower the temperature inside the étuve to any considerable extent.

1,341. The stove used for attenuating the charbon virus is not the ordinary étuve Arsonval used in Pasteur's laboratory. The temperature at which the stove is to be adjusted is, in the case of the premier vaccine 104° C., and in the case of the deuxième 90° C. The jacket of the étuve thus must not be filled with water, as water will begin to boil at 100° C. A substance with a higher boiling point should therefore be used in filling up the jackets on the side and the top. Any ordinary oil serves this purpose. The capsules are kept for six hours inside the étuve both in the case of the premier vaccine and in that of the deuxième vaccine, after which the contents of the capsules are found to be quite dry. These are scraped out, well powdered, and stored in dry bottles and in dry places as premier or deuxième vaccine, as the case may be. A few grains of this powder well mixed with water is syringed into an animal to protect it from charbon in the locality where this disease is known to take place. The premier vaccine, which is weaker, is inoculated first, and after a few days the deuxième.

1,342. To regulate the étuves at a regular temperature of 104° C. in the one case and 90° C. in the other, a different automatic appliance is employed from that used in Pasteur's laboratory. The contrivance used by M. Arloing consists of a tube, closed at the lower end, and containing mercury and water, placed in a vessel of hot oil. The water used is pure water in the case of the étuve for the deuxième vaccine, *i. e.*, where a temperature of 90° C. is sufficient. In the case

of the other étuve the water is mixed with calcium chloride, the mixture having a higher boiling point than 104° C. The tube is in continuation with a narrower part which ends in a U tube, through which the larger supply of gas passes. When, however, the oil is hotter than 104° C. the mercury expands and drives the water before it so high that the passage of the gas through the U tube is completely cut off, the flame goes down, and the temperature of the oil goes down to 104° C. It cannot go down lower, however, for the water would go down also in the U tube and allow of the passage of some gas through the tube, which would make the flames larger, and the oil thus get hotter. The interception of gas at the U tube would have put out the gas altogether, and made the oil go down in temperature again, but for a constant supply of a very small quantity of gas directly to the burner through another India-rubber tube, which keeps the flames just burning. Very hot oil is poured in the jacket. When the thermometer after a time indicates a temperature of exactly 104° C., a mixture of water and calcium chloride is poured into the U tube, so as just to intercept the passage of the gas. The étuve keeps itself adjusted after this.

1,343. *Preparation of Anthrax Vaccines.*—Besides Pasteur's vaccines for anthrax, there are two more that are effectively employed as a protection against this plague. These are prepared in the Government Veterinary College of Lyons. The modes of attenuation employed were discovered by M. Chauveau, the former Director of the College.

1,344. The virulent virus is taken from a recently dead animal, with an ordinary sterilized pipette, in the usual manner, to be fully described hereafter in connection with that for Pasteur's vaccine. This is sown in a sterilized flask containing proved broth, and the culture of bacilli is allowed to go on in the flask by leaving it for 20 hours in an étuve regulated at a temperature of 42°C. When this period of time

has elapsed the vaccine (still virulent) is sucked into sterilized tubes, sealed at one end and having a cotton wool plug at the other. The sealed end is broken off, the tube passed through a flame four or five times with a twisting motion of the wrist, dipped into the flask, and a portion of the vaccine drawn in by sucking through the other end. When a sufficient quantity has been drawn in the end is again sealed. The cotton-wool end is also sealed beyond the cotton-wool, so as to obtain a sealed glass tube containing virulent vaccine. Several of these tubes are taken at the same time, placed on a rack. This rack is plunged in a vessel containing water kept by a similar automatic arrangement as has been already described, at a uniform temperature of 48° C. for three hours. At the expiration of this period of time the vaccine in the tubes is sufficiently attenuated for application in the usual manner to animals. This is the simplest and the quickest way of preparing anthrax vaccine.

1,345. The other method applied by M. Arloing in preparing anthrax vaccine may be described as follows:—

1,346. Virulent bacillus anthracis is obtained from an animal dying of anthrax in the usual way, and cultivated in broth in a sterilized flask. This flask is put inside an iron receiver, which is fitted on to a force pump, and oxygen, prepared in the ordinary way and kept in an air-tight India-rubber bag, is forced with this pump into the receiver. When the manometre on the receiver indicates from 2 to 2½, *i. e.*, when the pressure inside is 2 to 2½ atmospheres, the screws are turned and the charged receiver is put inside an étuve Pasteur for 14 to 20 days at a uniform temperature of 36° C. After the expiration of this time the attenuation of the vaccine is complete in the flask. But as only a small quantity is contained in the flask, it is sown in a large sterilized flask containing proved broth to increase the quantity. The flask is taken out of the oxygen vessel and its contents transferred to the large flask containing a large

quantity of broth. When, after a few days, the contents of the larger flask appears quite turbid, the cultivation of the bacilli is finished, and the vaccine can be used for inoculating animals to protect them from anthrax, two drops for sheep and four drops for cattle.

1,347. This method of attenuation is exactly opposite to that of Pasteur in this respect, that in Pasteur's method spore formation is suppressed, whereas in Chauveau's method spore formation goes on profusely inside the oxygen vessel.

1,348. *Pasteur's method of preparing anthrax vaccine* consists in keeping the virulent vaccine for 20 days at a uniform temperature of 42° to 43° C. in the preparation of the weaker or premier vaccine; and at the same temperature for 12 days in the preparation of the stronger or deuxième vaccine.

1,349. It may be here remarked in passing, that the periods of time, or the degrees of temperature mentioned throughout this Chapter, need not be so exact. If, for instance, instead of keeping the virulent vaccine for 12 days in the étuve at 41°, 42°, 43°, or even 44° C., one were to keep it for 15 days under the same conditions, the character of the vaccine will not be much different. The figures used are the most favourable. But if an accidental departure to a small extent takes place, it does not do any harm. They are not exact to a degree and a day or an hour, as the case may be, in either Pasteur's laboratory or in the laboratory at Lyons. When, however, the time prescribed is three hours, it will not do to have it only one hour or one day. In this case a difference of a few minutes is of no consequence.

1,350. In M. Pasteur's laboratory the preparation of the vaccines is not taught. The above description was compiled by the author at the Veterinary College laboratory at Lyons and also at Professor Duclaux's Laboratory in Paris. What is taught in Pasteur's laboratory is how to manage the

vaccine seed when it is obtained; and how, with the broth which is also supplied by this laboratory, the small quantity of vaccine seed can be made to produce a large quantity of vaccine for the purpose of inoculating animals on a large scale.

1,351. It may be here asked, why not get vaccine from Pasteur's laboratory directly instead of mixing the seed with the broth in India, and thus making it necessary to have a laboratory containing such implements as the Etuve Pasteur, another étuve for sterilizations, blowpipes, gas, glasses of different kinds, and so on? Why not get the vaccine ready made from Pasteur's laboratory as is done in European countries? The objection to this lies in the fact that the bacillus anthracis is an ærobic germ requiring air or oxygen to keep it alive. Spores of the bacillus, however, can live without air. But spores alone, if introduced by inoculation into the bodies of animals, may or may not germinate. Vaccination with spores alone is very uncertain. Even in sending vaccine to European countries packed up tightly it is necessary to put in a little vaccine which contains a large proportion of spores. The filaments do generally retain their vitality for two or three days, and even more, but probably because there is always a little air in suspension in the vaccine, and also a little between the fluid and the stopper. The cases of failure in Europe with Pasteur's vaccine may be explained in fact from this very circumstance. Sometimes when the vaccine is applied all the ærobic filamentous bacilli are dead, and the spores,though alive, fail by their nature to vegetate inside the animal body, and no vaccination takes place. It is for this reason necessary to have a laboratory in a place which is several days' journey from Pasteur's laboratory.

1,352. It is not necessary to depend upon Pasteur's laboratory for seed, *i.e.*, the vaccine spores, but it can be prepared by one of the methods already described. But whether the vaccine is received from Pasteur's laboratory as

"seed," or prepared locally, it will be necessary to have a laboratory. And also to have,—

(1) Blowpipe flames, for making vaccine tubes, *tubes effiles* and pipettes, and for sealing broth flasks, tubes, &c., when necessary.

(2) A refrigerator, to preserve the vaccine seed throughout the year, unless the laboratory itself is situated in a hill station. Premier vaccine keeps for two years, and deuxième for one year without degenerating or losing their strength, if they are kept at a very low temperature. The vaccine also, when it has been made, is kept in a cool place below 23°C., and this temperature cannot be naturally obtained in the plains in India. From this it will appear that it will be probably impossible to carry on vaccination operations in India during any other season than winter. In Europe it is done only during the spring.

(3) An Etuve Pasteur for the cultivation of the premier vaccine, and another for that of the deuxième. Different shelves of the same étuve will answer if only a small number of flasks have to be cultivated. In Pasteur's laboratory a whole room is converted into an étuve, and one portion of it is used for the premier vaccine only, and another for the deuxième. But as a difference has to be made between the "new" and "old"—*i.e.*, the filamentous vaccine, which is more useful, and which is obtained during the first days of cultivation, and the sporular vaccine, which is obtained if the cultivation is allowed to proceed for ten days, and which is mixed with filamentous vaccine if the vaccine has to be sent packed up to some distance—it is best to have two étuves to avoid confusion.

1,353. The Etuve Pasteur consists of (1) a shelved chamber, with double boards and double glass doors, the lowest shelf being covered up, communicating with the upper board by means of several holes, and containing inside it a worm or coil filled with distilled or boiled water; (2) a gas

stove for heating the water contained in a boiler surrounded with a flue; (3) a condenser for receiving and condensing the steam passing from the boiler on the stove through a coil of pipe passing in contact with the distilled water coil in the covered up shelf of the chamber into the condenser; (4) two India-rubber tubes connected with the gas pipe, the narrower one allowing a small quantity of gas always to pass to keep the flame continuously burning a little, and the larger one, instead of passing directly to the gas burner, passes through a meter or indicator which automatically adjusts the passage of gas through this tube. When the gas burner is fully supplied with gas, the heat produced is great, and the distilled water in the coil is heated and its bulk increased. If the heating is more than enough, a column of water will be seen rising in the glass tube or indicator. This column will exert pressure on the India-rubber disc alongside which the gas has to pass. This pressure is sufficient to close the aperture through which the gas passes either wholly or partially, diminishing automatically the flame under the boiler. The temperature in the chamber is thus kept uniformly at 35°C. in the lowest shelf, and 32°C. in the next, and about 29° in the top shelf. The top shelf may be wholly set apart for those flasks which have been just sown with the seed, and the next shelf for flasks with seed sown the previous day. On the third day the flasks are taken out, all but a fourth or fifth part of them, and removed to a cool place to prevent further vegetation, for if the temperature was above 26° or 27°C., quick vegetation will continue, and the filamentous character of the vaccine would be changed into sporular, and vaccination with such vaccine would not be certain. When vegetation proceeds rapidly in the étuve for the first three days the flasks are in it after the sowing of the seed, there are very few spores formed, but afterwards there is more profuse spore formation, unless the vegetation of the vaccine is retarded by being kept in a cool place (23°C.). A fourth or fifth portion of the flasks is allowed

to remain in the étuve and the vegetation to proceed, as it is useful to mix a little "*ancien*" or sporular vaccine with the more effective filamentous vaccine when vaccine is sent tightly packed up to a distance. This same remark holds good for premier as for deuxième vaccine. But as the deuxième vaccine is much stronger than the premier, *i.e.*, capable of killing an animal not previously inoculated (only about twelve days before) with the premier vaccine, it is very important to keep the two entirely separate from each other, and hence the necessity of two étuves.

(4) An Etuve Arsonval, for attenuating the virus for the first time. As a constant higher temperature (42° C.) is necessary for preparing the seed of the vaccine than that required for cultivation of the vaccine (28° to 32° C), a separate apparatus is necessary for this purpose. The Etuve Arsonval already described in connection with the preparation of charbon vaccine is the apparatus used, with this difference only that hot water is put in the jacket instead of hot oil, and the indicator is a glass tube exactly similar in arrangement to that in the étuve Pasteur.

(5) A *four-á-flamber* or a flame furnace. This is a sheet-iron cylindrical stove with three jackets standing on a gas burner. It is used for sterilizing (*a*) *matras Pasteurs*, or vaccine flasks and seed flasks; (*b*) *ballon pipettes*, or large pipettes, used for transferring broth from sealed flasks to the matras, and also for filling vaccine tubes; (*c*) *tube effiles*, which are used for sowing seed in chicken broth first, and also for sowing the vaccine in veal broth for increasing the quantity; (*d*) vaccine tubes, which are used for sending vaccine to a distance.

(6) Sulphate of copper vat, the solution being made with one of sulphate of copper to 100 of water. In this is thrown all the dead bodies of animals dying of anthrax, &c., after experimental inoculation.

(7) A fold for larger animals, and a room with boxes of

small animals, such as rabbits, guinea-pigs, goats, &c., to be used for experiments.

(8) A microscope magnifying 500 diameters, slides, cover glasses, and a basin of sulphate of copper solution for putting aside all microscopic preparations before washing.

(9) Stoves for making broths, weighing machine, tubes, matras, ballon pipettes, cotton-wool (for plugging matras, pipettes, &c., before putting them in the stove for sterilizing), India-rubber stoppers for vaccine tubes, spirit lamp, potash for washing slides and cover glasses.

(10) An auto-clave for clarifying and sterilizing broth.

The operations necessary follow each other in the following order :—

(1) Sterilizing the glasses with cotton-wool plugs, and keeping a stock ready sterilized of each kind.

(2) Preparing the veal and chicken broths, and having a stock always ready in sealed flasks.

(3) The sealed flasks are opened by rasping their neck with a steel knife and cracking them off with an ignited piece of Berzilius charcoal. A sterilized ballon pipette is taken, the smaller sealed end nipped off, passed through flame, introduced into the broth, the broth sucked into the pipette and poured into the matras, veal broth being poured into the larger flasks for the preparation of vaccine, and chicken broth into the smaller matras for sowing seed. The matras are left from 8 to 15 days in the lowest shelf of the Etuve Pasteur to prove their sterility, in case any germ might have found its way in any of the flasks while the pouring of the broth was being done. The flasks or matras of broth are then brought out and kept in a cool place to prevent evaporation and oxidation to any extent. This stock can be used for sowing seed or vaccine for 20 days to one month. After that the broth gets too strong, being reduced in bulk by evaporation, and it also becomes oxidized, and therefore a fresh supply must be drawn from the sealed flasks again, or broth newly made.

In sealed flasks they keep unaltered for an indefinite period of time.

(4) The blood is drawn out with a sterilized pipette from the heart of the animal recently dying of anthrax. With the microscope it must be ascertained that it was anthrax. Then the animal is carefully dissected, so as not to puncture the heart. A piece of strongly heated glass is rubbed on the part of the heart to be punctured with the pipette, and then the pipette, is put in and the blood sucked into it. This blood is sown in chicken broth to cultivate the bacilli. After three days it is seen whether it has altered, or whether the culture obtained is of pure bacillus anthracis. This can be judged by the naked eye by gently inclining the flasks and seeing against a light whether the culture is filamentous and sunk in the clear broth. Every flask, whether of broth, of virulent virus, or of vaccine, must be daily examined to see if any of the disturbing organisms have been growing in them. They can be easily detected with the naked eye if the flasks are held against a light, but in any case of doubt the microscope must be used. The usual disturbing organisms are (1) the *points doubles* or diplococci, which give the broth or vaccine a dull troubled appearance, and when more than one day old a white deposit settles on the bottom of the flask; (2) penicillium and aspergilius fungi, which float on the top in lumps; (3) bacillus subtilis, which produces a veil or film on the top; (4) *trainees*, which form white lines sticking to the sides of the glass as rays; and (5) bacterium termo, which also troubles the clear liquid, and, looked at through the microscope, appear as minute corkscrew shaped rapidly moving vibrions, smaller than bacillus anthracis. At every stage, therefore, it is necessary to be careful that any other organism than bacillus anthracis is not being cultivated as bacillus anthracis. When the blood sown in the chicken broth has been three days in the Etuve Pasteur, it has to be particularly seen that it has given rise to a culture of bacillus anthracis only in the flasks.

(5) When a pure culture of the virulent virus has been obtained, a portion of it, say one flask out of three, is left for ten days in the étuve, and the other two drawn out. The one remaining in the étuve for ten days gives rise to a sporular virulent vaccine, which is useful for testing whether vaccination has been done or not. In other words, when animals have been vaccinated with the premier vaccine, and twelve days after with the deuxième vaccine, a portion ot them ought to be vaccinated twelve days after with the virulent vaccine also, to see if it kills the animals, or the previous vaccinations have had the effect of protecting them from the effects of the virulent vaccine. If the animals die something must have been wrong with the preparation of the vaccine or the inoculation, and the operation has to be gone through again. It is thus necessary to have a stock of virulent vaccine also. When the virulent virus has been ten days in the étuve it is taken out and sucked into sterilized pipettes, the two ends sealed, and the sporular virulent vaccine "seed" is thus preserved for more than a year, as the spores of bacillus anthracis can live without oxygen.

(6) The premier and deuxième vaccines are also kept in stock in sealed tubes in their sporular state. When the virulent vaccine is taken out of the stove on the third day in its vegetating or filamentous condition it is subjected to the attenuating process, *i. e.*, it is kept in the Etuve Arsonval for 12 days at 42° C. or 43° C. to prepare the deuxième vaccine, and for 20 days to prepare the premier vaccine, which is more attenuated and weaker. This high temperature attenuates the vaccine. It is then taken out of the stove, and left for 10 days in the Etuve Pasteur for the vaccines to change into the sporular state. When it is in the Etuve Arsonval for 12 days or 20 days for attenuation it retains its filamentous character; but when brought back again to the temperature of 28° C. to 32° C. in the Etuve Pasteur, the most favourable temperature for culture, the vegetative

process proceeds, and spores are formed. This sporular state or "seed" of the premier and of the deuxième vaccines can be preserved in sealed tubes for over one year. At the beginning of the season, therefore, the seeds of the virulent, premier, and deuxième vaccines are obtained, and they are stowed away in sealed flasks in a refrigerator at as low a temperature as possible (0° to 15° C.).

(7) The sealed tubes containing the premier, the deuxième, or the virulent vaccine is opened by nipping of the wider end, the seed sucked into a small pipette or *tube effile*, and sown into chicken broth, three flasks for every tube of seed. They are left for three days at 30° to 32° C. in the Etuve Pasteur, and then brought out and kept in a cool place. They can be used for 15 days after they are taken out *i. e.*, five days are allowed for each flask.

(8) During these 15 days the contents of the three small flasks can be sown into large flasks containing veal broth. These large flasks are also left for three days as premier or deuxième vaccine in the Etuve Pasteur for culture, after which it can be used for inoculating.

(9) For despatch, a small quantity of vaccine (sporular or *ancien* vaccine), kept 10 days in the étuve, is mixed with the fresh or filamentous vaccine in the ballon pipette before introducing it into a vaccine tube and putting the India-rubber cork on it. The vaccine tubes being all sterilized with brown cotton wool plugs, these plugs are taken out, the vaccine poured into the tubes by a twist of the ballon pipette, an assistant passing India-rubber stoppers at the same time through the flame, taking the tubes one after another just filled into his hands, and putting the plugs in with a corkscrew motion.

(10) Performing of the vaccination, first with the premier, then with the deuxième, and then for experiment only on a few of the animals with the virulent vaccines. The Pravaz syringe is used for this purpose, the leather rings of which

are renewed, and the syringe boiled and cleaned, after every series of operations.

(11) All vessels coming in contact with the deuxième or the virulent vaccines have to be boiled before cleaning.

1,354. Some general remarks regarding the effect of temperature on bacillus anthracis may be noted here for guidance in the above practices :—

(1) The bacilli are not cultivated under 16° C.

(2) At 16° C. they do not give spores, at least not for a long time.

(3) At 45° C. they are no longer capable of cultivation in chicken broth.

(4) At 42° to 45° C. the culture goes on rapidly, but only of filaments. Scarcely any spore formation takes place at this temperature. This is the temperature used by Pasteur to attenuate his vaccine, about 12 days being allowed for the second or stronger vaccine, and 20 days for the weaker or first vaccine.

(5) The most favourable temperature for the development of the filamentous as well as the sporular states of the bacilli is between 30° and 35° C.

(6) The filamentous bacilli are killed by a temperature of over 60° C., excess of CO_2 gas, or alcohol.

(7) Spores, however, are not killed under these conditions. They retain their vitality in vacuum also. Spores of bacillus anthracis are never found in the blood of the living animal. They are formed only when the blood comes in contact with the outer atmosphere. They resist a temperature of 95° C. for a short time only, and are certainly killed at 100° C., hence the use of boiling water.

1,355. It is curious to observe, however, that spores of bacillus anthracis which resist such adverse conditions are killed by the simple agency of the direct rays of the sun. M. Arloing has shown that the spores of bacillus anthracis contained in the broth of the culture exposed to the sun are

completely destroyed, whereas that the vegetating myclelia require rays of the sun for a much longer time. M. Nocardet and M. Duclaux have propounded the hypothesis that the action of the rays of the sun influences much more the culture than the spores themselves. To verify this assertion M. Straus proceeded as follows,—he placed spores in pure distilled water, and in these conditions they resisted the rays of the sun for four hours, whereas in broth they were destroyed in two hours. He found that an exposure to the sun for two hours was sufficient to destroy young spores, *i.e.*, spores not more than about three months old. Older spores resist the action of light longer.

1,356. If it is suspected that animals are dying of anthrax in any district, and if it is impossible for the proper authority to proceed to the spot at once, and ascertain the truth about it with the microscope, a local officer, or any other person interested, is to be instructed to inoculate a rabbit or a goat with the blood of an animal dying of the plague not more than 12 hours previously. If the blood was allowed to become putrefied, the rabbit or the goat would be inoculated with septic vibrions instead of bacillus anthracis, and it would die of septicimœa, and in this case it would not be possible to make a diagnosis for anthrax. This rabbit must be sent immediately to a bacteriological laboratory. If, when the animal is dissected *after death*, bacillus anthracis is discovered in the blood, the blood of the spleen and the heart must be specially examined before one should be quite sure, and then the local authority or the proprietors must be written to at once to have their flocks vaccinated in that district. Mortality will probably continue in the flocks even after the animals have been inoculated with the first vaccine. But 8 or 10 days after the inoculation with the second or the deuxième vaccine mortality should cease. If mortality continues after this complete vaccination, it would be caused by a very great intensity of the disease. Then a special

vaccine called "vaccine for revaccination" must be sent for. The inoculation of the deuxième vaccine is made 12 to 15 days after that of the premier, 15 days being the extreme limit. After this time the first vaccine is to be re-inoculated, as the deuxième would probably be too strong when inoculated after this lapse of time. One-eighth c. c. is inoculated of both the vaccines to small animals, and ¼th c. c. to larger animals. Elephants ought to have ½ c. c. No treatment has to be resorted to when œdema takes place at the point of inoculation. How long the effect of vaccination lasts is not certain, it is considered safe to vaccinate every year 60 per cent. of the animals vaccinated the previous year. A flock already vaccinated, if it becomes accidentally subject to anthrax, must be *revaccinated* at once, if the mortality breaks out *within* an interval of three months. After three months complete vaccination, *i. e.*, a repetition of the premier and the deuxième vaccinations, must be resorted to. The vaccine for revaccination is prepared in this way, in a ballon pipette. A mixture is made of the first or premier vaccine, recent and old (*i. e.*, filamentous and sporular). In another ballon pipette a mixture of the second or deuxième vaccine, recent and old, is made. The vaccine tubes for despatch are filled half with the premier and half with the deuxième vaccines so mixed in the ballon pipettes.

1,357. Even with all these precautions vaccination may fail in certain cases, and it cannot be accounted for. The processes are so many, and the opportunities of making mistakes present themselves so often at each stage, that it can be easily understood how difficult it is to explain how some failures occur.

1,358. When disease does not exist in a flock, *but only in this case,* it is preferable to vaccinate the dams when they are not pregnant, or only in the first stage of their pregnancy, otherwise abortion may occur. It is necessary to vaccinate lambs as soon as spontaneous disease is feared. Cows fall

off in milk when they are vaccinated, and it is good to vaccinate them when they are dry. The milk from cows recently vaccinated must be boiled before it is drunk. If malady does not exist during the suckling period it is best to wait until the weaning. Sheep are vaccinated in the inner part of the thigh, the premier on the right thigh, and the deuxième on the left: oxen and horses behind the shoulder, sometimes before, lest the collar should press on the place of inoculation. It is well to shave off the hair of the part before inoculating, lest the orifice of the syringe should be blocked up with a hair and prevent inoculation. When a vaccine tube has been uncorked once it must not be used a second time; what remains over after the first series of operations must be rejected, and not reserved for another place or occasion.

1,359. *Preparation of the Broths.*—For the preparation of anthrax vaccine, the best nutrient fluid to use is chicken broth; but, as it is dearer than veal broth, which is also very good, chicken broth is used only for sowing "seeds," or the sporular condition of the virulent, deuxième, and premier vaccines. In both cases, however, the same proportion of meat and water is used, *viz.*, 250 grammes of meat to 500 grammes of water.

1,360. Bones and fat are rejected, the meat is then minced or triturated by passing it through a machine (the one used at M. Duclaux's laboratory being constructed by Messrs. Spong & Co., of London). This machine, somewhat like a small turnip cutter, is fitted on to the corner of a table. A weighing machine is also on the same table to weigh the meat and the water. The meat and the water are then put together in a glass vessel, covered up and laid aside for 24 hours in the cold weather, and 12 hours at night in the hot. After the 12 or 24 hours the mixture is boiled for half an hour with continual stirring, and passed through a calico filter, and then through a filter paper into

a large flask. Before filtering the broth, the filter paper must be filled with water to see that there are no holes in it; the solid particles are then pressed with an ordinary meat press, the fluid squeezed out, and added to the filter. The filtered broth is made slightly alkaline by gradually adding a few drops of potassium hydrate, stirred, and tested with a piece of turmeric paper. When slightly alkaline a cotton wool plug is put in the flask, and it is put inside an autoclave, where the heat generated is 115° to 120° C. There is no thermometer attached to indicate the heat, but the machine is so constructed that, whenever the pressure of the steam inside raises the temperature beyond 120° C., a safety valve allows some steam to escape. The manometre indicates the pressure, but the machine is self-adjusting. If the liquid in the flask is half a litre, five minutes of steaming is quite enough; if five litres, 20 minutes is necessary to clarify the broth. The lid of the autoclave is fastened with hooks to retain the pressure of the steam.

1,361. When the five minutes (or 20 minutes, as the case may be) are over, the gas is to be turned out, and the steam allowed to escape very gradually. When cool, the lid is to be opened and the flask taken out. The broth is now clarified, and the precipitate will have to be removed by filtering again. The filtering is done into flasks with very long necks, and when about three-fourths full, the flasks are sealed at the lower part with a blowpipe flame by continual turning, and the long neck is broken off and thrown away. The sealed flasks are then put inside the autoclave again at 115° or 120° C. for 15 minutes to sterilize the contents, that is, to kill any organic germs. When out of the autoclave, the flasks of broth can be kept in store for any length of time, and for use, the sealed neck will have to be rasped and cracked open, and the broth transferred with the help of a ballon pipette into matras. Lest any organism should settle in these operations, the matras are left for 8 to 15 days on the

last shelf of the Etuve Pasteur for proving their sterility. If the contents of any flask should alter, it would, of course, be rejected.

CHAPTER CXXX.

THE HIGHER FUNGI.

THE commonest of these fungi, which show distinctive mycelia and spores, are known by the name of moulds. The *green mould* in cheese, bread &c. is caused by the Penicillium glaucum. The *blue mould* is caused by the Aspergillius fungus, and the *white mould* by the mucor. The Oidium of *dahi* spoken of before is also a common fungus.

1,363. Instead of giving a systematic classification of the higher fungi, we will go at once to the description of the principal disease-producing fungi which will give some idea of the life history of these plants. Mushrooms are also included among these higher fungi, and a description of the cultivation of edible mushrooms will follow in the next Chapter.

1,364. *Potato-rot* (Peronospora infestans).—This disease well recognized by the peculiar stinking smell of the tubers, as also of the plants affected with it, is caused by a fungus known as Peronospora infestans. Dark patches appear on leaves first, then a white bloom both on upper and under surfaces, but chiefly on the under surface, of the leaves; the stems are then attacked and finally the tubers. The disease sometimes makes very rapid progress specially in wet weather. Fortunately for us the potato crop growing at the dry season, the potato-rot has never been known in the plains of Bengal. An average temperature of over

77° F. or a temperature lower than 34° F. is unsuitable for its propagation, the temperature most suitable for its propagation being between 50° to 60° F. The tomato and some other solanaceous plants are also subject to the attack of the fungus and it is necessary to suspend the cultivation of all these crops for 2 or 3 years when the potato-rot appears in any locality.



FIG. 74.—PERONOSPORA INFESTANS.

Explanation of the figure.—(*a*) Section through an infected potato-leaf, showing greater protrusion of the fungus from the under surface than from the upper surface of the leaf (×50). (*b*) Conidiophore with conidia shown greatly magnified (×250) (*c*) and (*d*) Zoospores coming out of a conidiophore. (*e*) Germinating zoospore. (*f*) Promycelium from zoospore. (*g*) Promycelium growing directly out of a conidiophore. (*h*) and (*j*) Oogonia and Antheridia inside the potato-leaf shown enlarged (×250). (*k*) Germinating oospore. (*l*) Zoospores coming out of an oospore. (*m*) Germinating zoospore.

1,365. If a particle of an affected leaf is examined under the microscope it will be seen that the fungus grows chiefly at the lower part of the leaf, and the growth is downwards from leaf to stem and from stem to tuber. The mycelium or spawn-threads will be found branching out and bursting through the stomata of the lower surface, and wherever one

of these threads comes in contact with a leaf-cell the latter gets discoloured and putrefied. Occasionally a thread comes out at the upper surface also (vide Fig. 74 *a*). The stomata getting blocked up with mycelia, transpiration is prevented, and putrefaction hastens. Conidiophores, *i. e.*, jointed branches bearing little fruit-like bodies (conidia), appear chiefly at the under surface. The conidia observed under a high power microscope magnifying about 250 diameters will be found to be divided into compartments; and if a conidium is placed on a moist substance, each compartment will be found coming out as a ciliated zoospore and sailing about in the slightest film of moisture. These zoospores after a little time become non-motile and more spherical. After resting awhile each zoospore, if properly conditioned, throws out a mycelium and thus the life of the parasite is repeated.

1,366. The conidia also sometimes throw out pro-mycelium without producing zoospores. The conidia are carried about with the wind, and the zoospores swim over the surface of leaves bedewed with moisture, and the infection spreads in this two-fold way. Insects and birds also act as carriers of infection from field to field. When the mycelia reach the tubers, they decompose the cells and corrode the starch. In bad cases the tubers rot altogether, but in mild cases the mycelium hibernates in the tuber and becomes perennial and these tubers which contain the disease in an undeveloped form may give rise, when they are used as seed, to potato-rot in the next crop. But perennial mycelium cannot survive an unusual amount of heat, cold or moisture, and *diseased seed-potatoes, therefore, do not necessarily produce a diseased crop.*

1,367. Besides the non-sexual reproductive functions by means of mycelia and conidia (which usually form zoospores as an intermediate stage before the pro-mycelial growth), peronospora infestans is reproduced by sexual means also. If a section of the leaf intersected by mycelial growth is

closely observed, little thickenings and buds will be observed in the mycelia themselves as apart from conidiophores. These thickenings and buds are called Oogonia and the enclosed cells Oospheres. Smaller buds growing out of the mycelia will be also noticed which are called the Antheridia. The Antheridia are the male cells and these coming in contact with Oogonia, and the protoplasm of the Antheridia flowing into the Oospheres, fertilisation takes place and Oospores are the result. These fertilised Oospores are also called Resting Spores. They are round and sometimes smooth and sometimes spiney in appearance looked at under a powerful microscope. The Oospores abound in diseased seed-potatoes after they have germinated and spent themselves. The perennial mycelium in the tuber, not being able to produce conidiophores and conidia (which require contact with free atmosphere for their development), develops oogonia and antheridia as it multiplies. As zoospores give rise to germinal threads so do oospores when kept uniformly moist and warm. The oospores are of brown colour and thus easily distinguished from zoospores, which are almost colourless. The oospores, having a longer vitality than zoospores, and remaining in old potato fields in decayed tubers and old leaves and haulms, they germinate again next summer and it is usually by their means and not by means of the perennial myclia of the seed-tuber, that potato disease reappears year after year. As the potato-disease spreads from leaf to stem and from stem to tuber and as it is never observed to take the opposite course of development from the tuber upwards, the source of infection is not so much the seed-tuber as the decayed haulms and tubers of the previous year. It is not necessary for the mycilial growth from the oospore to take place on the leaf of the potato plant itself. The fungus can grow at first on the moist soil and then gradually spread by means of conidia and zoospores to the leaves of the new crop. The source of infection being chiefly the

previous year's decayed tubers and haulms whether lying in fields or in manure heaps, and the oospores, which possess greater power of resisting climatic conditions than the non-sexual reproductive tissues such as mycelia, conidia and zoospores, germinating in the hill districts in spring at or immediately before the potato sowing season, the treatment indicated is both preventive and curative. Sulphate of copper solution or corrosive sublimate may be sprinkled on the field with the help of a knapsack vaporiser immediately before the potatoes are sown. Then the crop should be carefully watched and if any black patches and white bloom appear at the lower surface of the leaves at any portion of the field, the vaporising should be repeated. One preventive and two curative treatments should be sufficient. But if treatment is not feasible all over a tract affected with potato-blight, it is best to give up potato cultivation for three or four years, that the vitality of the resting-spores may die out before potato cultivation is resumed in that tract. This is how the potato blight which ruined the crops in the Darjeeling hills about ten years ago, had to be faced. There was entire suspension of potato cultivation for three years all over these hills, and since then the disease has not reappeared.

1,368. In France, the potato-blight was successfully combated with the help of the *Bouillie bordelaise*, or the Bordeaux mixture which consists of a half per cent. solution of sulphate of copper in hot water to which a quantity of milk of lime is added. This was applied with the help of the knapsack spraying machine called Eclair Vaporiser, both before sowing and two or three times after germination of the seed, during the growth of the crop.

1,369. *Rust*.—This is a disease of cereal plants caused by a minute fungus known as Puccinia graminis. There are different species of Puccinia graminis, the commonest of which attacking wheat, is called Puccinia rubigo-vera. This puccinia is different from the puccinia known to attack oats or

barley plants. Barley plants growing in the midst of rusted wheat at the Sibpur Farm were found entirely free from rust, but barley is also subject to a rust.

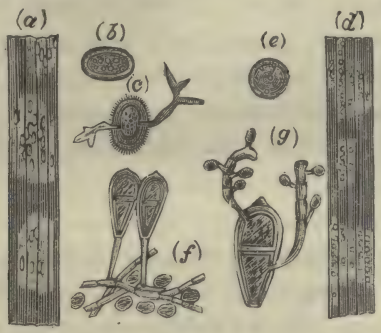


FIG. 75.—PUCCINIA GRAMINIS.

[(*a*) Large oval sori in clumps on a blade of wheat. (*b*) One uredospore detached from its clinode or stalk (× 300). (*c*) A germinating uredospore. (*d*) Smaller, detached and round sori of Puccinia graminis var. rubigo-vera. (*e*) A detached rubigo-vera uredospore (× 300). (*f*) Two teleutospores attached to their clinodes. (*g*) Promycelial growth from the two sections of a teleutospore, showing also sporidia borne on short stalks.]

1,370. The fungus was first noticed by Fontana an Italian botanist in 1767, but its biology was first studied by the great German botanist, de Bary. De Bary discovered that the fungus has three distinct stages, (1) the uredo or the orange colour stage, (2) the teleuto, or the black colour stage, and (3) the æcidial stage. De Bary also discovered that the æcidial stage of the fungus was passed in a different host plant altogether, such as the bramble, the barberry, or the borage, and not in the cereal plant affected. Dr. Prain discovered, at the Sibpur Farm, all the three stages of the fungus on a common weed belonging to the order Compositæ locally known as *tikchoná* (Launea asplenifolia). The absence of the teleuto-stage in the wheat-rust at Sibpur may be accounted for, according to the same authority, by its presence in the *tikchoná*. The connection between wheat-rust and the Puccinia fungus found on *tikchoná* has not however been

satisfactorily established as yet and it may be looked upon in the light of a theory for the present.

1,371. Jacob Eriksson, a Swedish botanist, who has recently made a very minute study of rust, has discovered that the black or dark-brown rust (teleuto spores) of wheat retains its germinating power for two winters. This is a discovery of great practical usefulness, as the lesson to be derived from it is that the cultivation of wheat should be suspended in a particular locality for two years after there is a severe attack of rust. The utility of such suspension will be further apparent from another of Eriksson's discoveries, *viz.*, the spores of rust travel only 10 to 25 metres from the source of infection. So if a field shows rust very badly one year there is no reason why a field 30 or 40 yards away from it should not be cultivated with wheat the next year. Eriksson has made another important discovery with regard to rust, that is, the infection may come either from uredospores, or teleutospores, or æcidiospores, or from a corpuscular germ of the fungus discovered by Eriksson in the seed itself. The microscopic appearance of these corpuscles is oblong, slightly recurved and occurring either singly or united. These germs give rise to intercellular mycelial development.

1,372. Humidity and heat are alone required for germination of uredo and æcidiospores. Teleutospores require a period of repose before it is active. In pickling wheat seed before sowing one kills only the teleutospores. The other sources of infection are not done away with. So even after sowing pickled wheat seed one may have rust in wheat, the infection coming from the æcidia or cluster cups on some other plant, or uredospores blown along by the wind from other wheat plants, or from germinal corpuscles inside the seed. The æcidial stage, at least in the case of Indian wheat rust, not being definitely established, only the uredo and teleuto-stages are represented in the annexed figure (Fig. 75).

1,373. Linseed, mustard, gram, *khesári*, and beet are also subject to distinctive rusts caused by fungi closely related to Puccinia. Melampsora linii causes the linseed rust. Another Melampsora causes rust in mustard and rape. Uromyces fungi cause rust in pulses and in beet.

1,374. The commonest Indian rust which affects *juár*, *bájrá*, *shámá* and some wild grasses, is known by the name of Puccinia Penniseti. The red patches on *juár* and other leaves affected with this fungus are due to uredo pustules. It should be noted however that certain races of *juár* are naturally almost immune against this disease. These should alone be selected for seed. Attempt is being made to establish stocks of wheat which would be immune against rust, but so far no definite results have been obtained by the use of the so called rust resisting varieties in India.

1,375. *Smut* (Ustilago).—This is another disease of cereals chiefly affecting the *juár,* but noticed also in paddy, oats, wheat, barley, *bájrá*, maize and *shámá*. It is caused by a minute fungus called Ustilago segetum (or Ustilago zeæ-mays, the variety which affects the maize). It affects chiefly the grain while rust affects chiefly the leaves and only indirectly the grain. The loss due to smut is not, however, so great in this country as that caused by rust, except in the case of *juár* and *shámá*. An ear-head here and an ear-head there may be seen affected with smut almost in any corn field, but wholesale destruction due to smut is not known in the case of wheat, barley, or oats. In June and July, are commonly seen smutted grass at Sibpur, and even earlier in the season one plot of *Khari* sugar-cane showed a profuse quantity of smut in 1901. It is a disease, however, which comes in connection with seeds, and if one is negligent about the harvesting of grains kept for seed it is possible to have smut in an epidemic form; while on the other hand, it is a disease which can be easily prevented by pickling the seed. The spores of the

fungus germinate after the seed of the cereal, with which they were entangled, has been sown. The germinating spore throws out one or more promycelium, from the joints of which are thrown out sporidia or conidia. These throwing out minute germinal tubes penetrate the tissues of the seedling of *juár* or wheat, or whatever the cereal may be, and once inside the tissues of the plant, the fungus grows up along the stem forming hyphæ and finally fructifying in the grains of the cereal affected. This is how all the grains on the ear appear smutted. It is curious, the fungus when it develops inside the stem of the cereal, scarcely affects the growth of the cereal. The sorghum grown at the Sibpur Farm in 1898 was nearly all smutted, and yet it was surprising how vigorously the plants grew. But when the cereal plant reaches the stage of fructification the fungus prevents seeding altogether and where the ears of grain should be there we see only a mass of black spores. But these sooty spores wafted by the wind affect healthy grains which get these spores entangled on their surface, and sown unpickled the next year, they again give rise to this fungus. In the case of the maize, smut-swellings appear on the stem as well as inside the cob.

1,376. It should be noted that *juár* stems and grain badly affected with smut are injurious to the health both of cattle and human beings, and death among cattle due to their eating stunted *juár*, though attributed to the stems containing an excess of nitre, may be also due to their being badly affected with the hyphæ of this fungus. But this subject is still considered a recondite one.

1,377. Dung of cattle fed on *juár* straw or grain affected with this fungus, is capable of retaining the fungus in an active state of growth for a long time, and if such dung is applied before it is thoroughly rotted by at least a year's fermentation, there will be liability for the manure giving rise to the fungus in the young cereal plants.

1,378. A smut destroying powder, called "Massel powder," is sold by a Belgian firm. This is sprayed on to a growing crop mixed up with lime water. Where the staple cereal is *juár* it may be worth while trying this powder. It is doubtful if any treatment can be effective after the fungus has once established itself in a crop. Pickling the seed with sulphate of copper solution (1 : 200) is the best preventive.

1,379. *Bunt* (Tilletia fœtens).—Bunt or stinking smut is also caused by a fungus (Tilletia fœtens), the life history of which closely resembles that of the smut-fungus (vide Fig 76). The rice plant is affected by it as well as wheat, barley and oats. The grains become abnormally inflated and they emit a putrid odour. The leaves and stems close to grains are also affected by the black spores. *Dhanér-gú* is the name given to the bunt fungus when it affects grains of paddy. The same fungus affects oats also.



FIG. 76.—SMUT AND BUNT FUNGI.

[(*a*) Spore of Ustilago (smut). (*b*) Spore of Ustilago throwing out promycelium with sporidia. (*c*) A germinating sporidium of smut. (*d*) Spore of Tilletia (bunt). (*e*) Spore of Tilletia thowing out promycelium with sporidia. (*f*) A germinating sporidium of bunt.]

1,380. Bunt spores adhering to grains not only give rise to bunt in the next crop when the grains so affected are used as seed, but they are far more injurious to health than spores of ordinary odourless smut. Headache, eruptions on the face,

indigestion and other forms of human ailment have been traced in some cases to the spores of bunt. When bunt is known to be amongst seed-grain, it should be steeped in some weak germicidal solution before use. Salt, quicklime slaked with boiling water, permanganate of potash, sulphate of copper and sulphate of soda solutions, have been recommended for use. The spores being lighter than water mere steeping of the grain in water is also efficacious, as the excess water afterwards run out usually carries with it all the spores which originally adhered to the grains.

1,381. *Sugar-cane Disease* (Trichosphœria sacchari).—This sugar-cane disease, due to a fungus, broke out a few years ago in the West Indies and Mauritius, and it has appeared recently in the Godavari District of Madras. The disease was first observed in Barbados in 1893, then in Trinidad, and then in British Guiana. In 1896 it was noticed in the District of Mozuffarnagar in the N.-W. P.

1,382. The diseased canes are first recognised in July or August by dark red or brown marks on the rind in one or two joints towards the middle or base of the canes. Up to the time of ripening in January or February, the red patches steadily increase in size and number. The fibro-vascular-bundles become less juicy, red and spongy in character. Fine looking thick and soft canes are specially affected. Towards the ripening of the canes black specks begin to appear which burst open from within outwards. These first appear near the roots and then work upwards, and then finally the affected cane shrivels up and dies. The Rind Fungus and Root Fungus, at one time considered different, are only two stages of the same fungus. The yield of sugar from a diseased plantation is very poor and the fungus in its epidemic form does very extended damage to the crop. Juice obtained from diseased canes, takes longer to crystallize.

1,383. Probably the fungus first makes its entrance at the middle of the cane at the spots where the sugar-cane borer

(Chilo simplex) has already made burrows for its offspring. But the rind fungus will be noticed in canes altogether free from injury caused by the borer or other insects. Perhaps the practice of tearing and breaking off of leaves at the time of tying and trashing, also helps in the lodging of the spores of the fungus in the rind.

1,384. Experience on the Sibpur Farm has shown us that superior varieties, such as the Chittagong "*Patna Kusur*," and the *Samsara*, are far more subject to the attack of this fungus than poorer varieties such as the *Khari* sugar-cane. It has been also seen that if tops are used for seed and if these are dipped in a solution (1 : 200 or 300) of sulphate of copper at the time of planting, the disease can be arrested. The old affected fields must be set fire to as also the dry leaves and trash accumulating at the time of harvesting and crushing of canes. Rotation should be invariably practised in cultivating sugar cane as the same field if it is used for growing sugar-cane year after year must become a hot-bed both for the condia of this fungus and for the grubs of the borer moth. Growing of canes from seed and then gradually establishing a healthy stock has been found beneficial in Java and other cane-growing localities where European planters are employed in the cultivation of cane. But the result from seedlings is always very uncertain.

CHAPTER CXXXI.

MUSHROOMS (AGARICUS COMPESTRIS).

IT must not he supposed that all fungi are noxious pests. Some of the mushrooms (which are one of the highest fungi) offer very palatable food, and if the food can be digested, it is very nutritious. Some mushrooms are very

poisonous, and the most practical methods of distinguishing edible mushrooms are :—(*a*) To taste a bit of the raw mushroom. If the taste is sweetish and pleasant it is quite safe to count it as an edible mushroom. If it has a bitterish or acrid taste it may be rejected as a poisonous one. (*b*) To rub a little bit of the raw mushrooms with the fingers. If the colour changes from white into green, the mushroom is poisonous. If the colour does not change it is a safe one to eat. But, it is still safer to rely upon imported French 'spawn' bought from the Great Eastern Hotel, or some other reliable firm, and grow the mushrooms from it in artificially prepared beds. The spawn incorporated with loose manure is sold by the Himalaya seed stores, Mussoorie, at Rs. 2/4 per box of 2lbs. This gives very good result. The best place to choose for mushroom-beds is a damp godown, where a specially prepared soil is to be spread to a depth of 18″. The soil should consist of 5 parts of garden mould, 10 parts of fresh horse-dung and 1 part of fresh ashes, thoroughly mixed up and exposed for two days to the sun before it is spread out in the godown. After 4 or 5 days, the spawn should be sown a foot apart each way. The spawn should be taken in pieces about 2″ square, dipped in water and sown in holes 3 inches deep covered up after sowing and beaten down firmly. After a month 2 inches of garden mould are to be spread over the bed, beaten down and well watered. No further attention is needed afterwards except occasional watering of the walls to ensure dampness of the atmosphere of the godown. If spawning is done early in September the first mushrooms will come up at the end of October. Small cellars are utilized in Europe for growing mushrooms on shelves fixed in the walls one above another. So grown, the mushroom crop may prove remunerative in this country also grown in towns like Calcutta where there a rich European population who value mushrooms as a delicacy.

PART VII.

METHODS OF ANALYSIS.

CHAPTER CXXXII.

GENERAL REMARKS.

THE sciences mainly helpful to agriculture are Geology, Mechanics, Botany, Chemistry, Veterinary Science, Zoology and Bacteriology. It is not expected that an agriculturist or scientific farmer should be an expert in all these sciences. In treating the subject of agriculture in a systematic manner it is impossible to ignore the geological, mechanical, botanical, zoological, physiological, bacteriological or chemical aspects of various questions with which the agriculturist has to do, and in the preceding Parts of this book facts culled from these sciences which are intimately related with agriculture, have been freely made use of in explaining the reasons and principles underlying those questions. We have already dealt with the chemical aspect of soils, crops, manures, &c., and in this Part, therefore, we will deal only with the methods that an educated farmer may follow for himself, without going to a chemist in analysing soils, manures and food-stuffs.

1,387. The main purpose of a knowledge of agricultural chemistry on the part of the agriculturist, is to enable him to analyse soils, crops, manures, purchased food-stuffs, milk, and industrial products, such as indigo, tea, sugar, dyes and tans.

In fact, the agricultural chemist is not expected to do even so much. There are specialists employed for the analysis of indigo, tea, sugar, dyes &c., and all that an agricultural chemist is ordinarily expected to do is to analyse with great accuracy soils, manures and food-stuffs. A chemist who cannot do this much but who has a great deal of general acquaintance of the different branches of chemistry, is of no use as an agricultural chemist Chemistry is a vast subject, and it is necessary to specialise one's work if one is to produce sound and reliable results. In analysing a soil in duplicate, for instance, if a student obtains ·5% of P_2O_5 by one analysis, and ·8% of P_2O_5 by the duplicate analysis, and if the soil actually contains only ·06% of P_2O_5, the work of the student is to be considered worse than useless. The duplicate results must agree up to the third place of decimal. Accuracy of manipulation, purity of the chemicals used, and a systematised arrangement helpful for getting over a large quantity of work, are the essential conditions of success in analytical work. The student of Agricultural Chemistry if he has already graduated in science in the University, should begin quantitative work at once. This disciplines him to methods of accuracy. One year of preparatory work in quantitative analysis will enable the student to produce accurate result in the second year. He should aim from the very first to do the work in the manner required for a *commercial analysis*. In analysing soils, for instance, he should aim only at getting the proportions of Soluble matter, Sand and other insoluble matters, Nitrogen, Phosphoric acid, Potash and Lime. In analysing a sample of Nitrate of Potash, however, the proportions of Sand, Sodium Sulphate, Calcium Sulphate and Sodium Chloride, should be ascertained, as these are impurities commonly present, and which may have been actually used by way of adulteration. In fact, adulteration is so universally practised in countries where manures are largely purchased, that it is never considered safe to purchase manure without analysis, and the time of the agricultural chemist in those

countries is mainly occupied, therefore, in analysing manures. In analysing crops, the agricultural chemist should also bear in mind the object, which is the ascertaining of their nourishing value. Another object of analysing a crop is to ascertain the proper manurial substances needed for its growth. The analysis of the tobacco leaf, for instance, leaves no doubt that the manurial ingredients required by this crop are chiefly N, Ca, S, and K, and one naturally arrives at the conclusion that Saltpetre and Gypsum would materially benefit this crop.

1,388. The agricultural chemist should be well acquainted with the aims, needs and difficulties of the farmer, that his analyses may not be aimless, but directed to the elucidation of only those points that would be of help to the farmer. In other words, an agricultural chemist must be an agriculturist who has specialised himself as an agricultural chemist.

1,389. The farmer also should have a general acquaintance of the chemical or rather the manurial value of the substances he sells out of his farm and those he buys for the farm. His aim should be to sell off only such articles as have little manurial value, such as, rice, maize, oil (not oil-cake), fibres, India-rubber, sugar, and butter; and he should buy such food-stuffs only as are particularly rich in N, P, K, Ca and S. Linseed-cake would fatten his animals quicker, but it is much better that he should purchase cotton-cake, as the latter brings in far more fertility to his soil.

1,390. The apparatus and chemicals required by an agriculturist for analytical work can be procured for about £200. Messrs. Baird and Tatlock of 14 Cross Street, Hatton Garden, London, E. C., are the best English firm to go to for these. For purity of chemicals, however, the firms of Kahlbaum of Berlin and E. Merck of Darmstadt, are the most famous. The best balance to use is that of Paul Bunge of Hamburg (price 10 guineas).

CHAPTER CXXXIII.

THE STANDARD ACID AND ALKALI.

THE strength of the Sulphuric acid to be used for the estimation of nitrogen, should be determined once for all and noted on the jars or bottles. This is done in the following way :—

Twenty cubic centimetres of the Sulphuric acid should be taken by means of a pipette into a clean beaker; then another 20 c. c. into another beaker; and a third quantity of 20 c.c. in a third beaker. Ten times as much distilled water should be added to each, *i. e.*, about 200 c.c. A few drops of dilute Hydrochloric acid should then be added to each. The contents of the beakers are then successively boiled, and when boiling just commences, solution of Barium chloride in a boiling state should be gradually added, and the contents of the beaker stirred with a glass rod, until all precipitation ceases. The liquid is to be kept near the boiling point for sometime, and then covered up and left in a sand-bath.

1,392. The liquid should then be brought to the boiling point and filtered, the next day, through Swedish filter-paper ; the precipitate on the paper being washed several times with hot water, also the residue of the precipitate in the beaker. When all the precipitate has been transferred into the filter, the funnel with the precipitate is to be covered up with a piece of paper and left on the water oven to dry. One precaution should be always taken before transferring the contents of a beaker into a filter, etc.: the edge of the beaker should be greased and a glass rod should be used while pouring the contents of the beaker into the filter. The filter-paper should be moistened with water blown out from a wash bottle before the liquid is poured on to it.

1,393. Next day, the precipitate is to be carefully scraped

out into a weighed crucible, the filter-paper burnt white, rolled up in a platinum wire coil, and the ash added to the precipitate. The crucible is to be placed on a piece of black glazed paper, while the precipitate and the paper ash are being put into it. The crucible is then to be placed on a Bunsen flame or spirit lamp and the substance thoroughly ignited. If any fragments spurt out, they will be noticed on the black glazed paper and they can be put back into the crucible. The crucible should then be left inside a desiccator for over ten minutes and then weighed. The precipitate in the three beakers is treated exactly in the same way, the estimation of the strength of the sulphuric acid being made in triplicate to ensure accuracy.

1,394. The addition of Barium chloride in the presence of Hydrochloric acid results in the whole of the Sulphuric acid in the beaker splitting up into $BaSO_4$ and HCl. $BaSO_4$ is nearly insoluble in water, but in dilute acid it is altogether insoluble. Hence the addition of a few drops of HCl.

1,395. The weight of the $BaSO_4$ being ascertained the weight of pure H_2SO_4 can be easily deduced.

1,396. Suppose the weight of the crucible + precipitate + ash of the filter-paper = 31·921 grammes, and the weight of the crucible alone = 29·336 grammes, and the weight of the $BaSo_4$ precipitate and ash of paper = 2·585. A deduction of ·002 is usually made on account of the ash of the paper, but this point may be separately determined by actual weighment of the ash from a piece of filter-paper of the size and quality used. The remainder, 2·583 grammes, is the weight of the precipitate. The weight of the precipitate of all the three beakers being thus ascertained, the average of the three weights is taken. If the weights come to 2·583, 2·584 and 2·6 grammes respectively, the average is $\frac{2{\cdot}583+2{\cdot}584+2{\cdot}6}{3}=$ 2·589 grammes.

Now $BaSO_4 : H_2SO_4 :: 2{\cdot}589 : x$

i. e., $173+32{\cdot}06+4\times16 : 2+32{\cdot}06+4\times16 :: 2\,589 : x$

$(=233{\cdot}06)$ $(=98{\cdot}06)$

$$\therefore x=\frac{98{\cdot}06\times2{\cdot}589}{233{\cdot}06}=\frac{253{\cdot}87734}{233{\cdot}06}=1{\cdot}089 \text{ grammes in 20 c.c.}$$

1,397. *The Standard Sodium Hydrate*:—The alkaline solution that has to be used for the determination of Nitrogen in all analyses, should be made of such a strength, that 100 c. c. of it should be exactly neutralized by 20 c. c of the standard sulphuric acid the strength of which has been just determined. This is done in the following way:—

A pipette-ful of H_2SO_4, *i. e.* 20 c. c., is taken in a white porcelain bason. It is diluted with about 200 c. c. of distilled water and coloured with an aniline colour. A burette-ful of the alkaline solution is then taken, and it is found, say, that the whole of the 50 c. c. of the alkaline solution in the burette is taken up without neutralising the acid. Another burette-ful is then taken and now, say, only 2·44 c. c. *i. e.*, 52·4 c. c. altogether, is required to neutralise the acid (when the colour just disappears). The whole of the alkali in the bottle is then transferred to another bottle, and say, 1100 c. c. measured back into the former bottle. Now as 52·4 of the alkaline solution requires 47·6 of water to make it into 100 c. c., how much water must be added to the 1100 c. c. to make it of the proper strength?

$$52{\cdot}4 : 1100 :: 47{\cdot}6 : x$$

$$\therefore x=\frac{1100\times47{\cdot}6}{52{\cdot}4}=999{\cdot}237.$$

So 999·2 c. c. of water has to be added to the solution in the bottle; and the burette filled with the new solution, and the process of decolourizing the 20 c. c. of H_2SO_4 coloured with an aniline colour, repeated. After 2 or 3 trials the exact strength can be attained.

Now we have seen, that 1 pipette of H_2SO_4 contains 1·089

grammes of pure sulphuric acid. But 1 pipette of this acid is neutralized by 100 c. c. of the standardized alkali.

$\therefore$ 1 c. c. of the alkali represents $\frac{1{\cdot}089}{100} = {\cdot}01089$ of H_2SO_4.

But H_2SO_4 neutralises $(NH_3)_2$ which contains 2 atoms of nitrogen ; *i. e.*, $2+32{\cdot}06+4\times16=98{\cdot}06$ parts by weight of H_2SO_4 is equivalent to $(14+3)\times2=34$ parts by weight of NH_3 and $2\times14=28$ parts by weight of N.

$\therefore$ ·01089 grammes by weight of H_2SO_4, or 1 c. c. of alkali represents $\frac{{\cdot}01089\times34}{98{\cdot}06}$ grammes of NH_3

and $\frac{{\cdot}01089\times28}{98{\cdot}06}$ grammes of N.

$\therefore$ Every 1 c. c. of alkali used represents ·00377586 grammes of NH_3
and ·00310952 grammes of N ;
and as albuminoid $=6{\cdot}33\times$ N,
it also represents $\cdot00310952\times6{\cdot}33$
$=\cdot0196832616$ grammes of albuminoid.

CHAPTER CXXXIV.

ANALYSIS OF SOIL.

IN analysing a sample of soil, for all ordinary agricultural purposes, the following constituents alone are quantitatively determined :—

(1) Moisture, (2) Organic matter, (3) Matters soluble in water, (4) Nitrogen, (5) Potassium, (6) Phosphorus Pentoxide, and (7) Lime.

1,399. The sample should be taken from different parts of the field, mixed up well, and must be thoroughly representative. It should be finely divided, spread out to dry in shade, and powdered with pestle and mortar, before it is bottled up or used for analysis. A steel box 9″ deep and 6″ square is hammered down and then dug out for getting representative samples of the top soil. In Bengal for ordinary crops, a steel box 6″ × 6″ × 6″, would answer.

(1) *Moisture*:—Three grams of the soil should be weighed out in a watch glass, and left in a water-oven, over-night. It is weighed next day when cool in the desiccator, and weighed again, after having been again left in the water-oven for a few hours, and then cooled in the desiccator. The weight should then be found to remain constant. The loss of weight is due to moisture in the three grams of the soil.

(2) *Organic matter*.—Ten grams of the soil should be weighed out in a Platinum crucible, and gradually heated to a low redness. The heat is maintained till all blackness disappears. It is then left to cool in the desiccator, and afterwards weighed. The loss of weight is due to organic matter and combined water as also to the moisture in 10 grams of the soil.

(3) *Matters soluble in water*.—Ten grams more of the soil should be weighed out, placed in a flask, 200 c.c. of distilled water added, and the whole boiled for a quarter of an hour with occasional shaking. The mixture is then kept aside for about 10 minutes, and the supernatant liquid decanted off into a beaker. The process of boiling with another 200 c. c. of water is repeated, and the second portion of the supernatant liquid is decanted off in the same way as before. This is repeated a third and a fourth time. The combined portions of the decanted liquid are passed through a double Swedish paper filter. If the filtrate is still turbid, it should be boiled, and passed through the filter again. This may have to be

done a third time before the filtrate comes out clear. This is transferred and carefully washed out into a small weighed beaker, left on the steamer to dry, the beaker being gradually filled up while on the steamer, and when apparently dry, it is left inside the water-oven, to get completely dry. Next day, it is cooled in the desiccator, and weighed. The increase in weight is due to the soluble matter in 10 grams of the soil.

(4) *Nitrogen.*—5 grams of the soil should be weighed out in a watch-glass and subjected to combustion for over 2 hours mixed up with dry soda-lime in the following manner:—A tube about 14″ long, drawn out to a fine point at one end and closed, and open at the other end should be taken. This is filled with hot soda lime. It is emptied on a clean porcelain bason, all but 1″. A funnel with a short stem is held, with the lower end stopped by means of the index finger of the left hand, while a portion of the soda-lime is poured on to it. Then the 5 grams of soil should be put on it. A little more of the soda-lime should be used to clean the watch-glass of any adhering particles, and this also transferred on to the funnel. The soil and the top part of the soda-lime are then mixed up with a spatula, the finger is slipt out, and the stem inserted into the combustion tube, and the mixture transferred into the tube. The remaining third of the soda-lime still on the bason, is poured down through the funnel to effect complete transference of all adhering particles of soil into the tube. About ½″ of asbestos plug should be then inserted, then the H_2SO_4-bulb containing 20 c. c. (1 pipette-ful) of H_2SO_4 is fitted on with a cork. The whole apparatus is then placed on a furnace, with the cork and the H_2SO_4-bulb fairly out of contact with the furnace. With the help of a spirit-lamp it is ascertained whether the apparatus is air-tight. The combustion is commenced from the near end of the tube, the last burner near the narrow end of the tube being lighted after 2 hours. With cold water the narrow end is

broken off, and the remainder of the NH_3, if any, sucked out through the other end. The H_2SO_4 in the bulb, now partially neutralised with the NH_3 coming from the soil, is thoroughly washed out into the beaker containing the residue of the 20 c. c. of the H_2SO_4 originally taken. This is transferred to a clean porcelain bason ; some Dimethyl Aniline is added as an indicator, and the standard NaHO solution is added from a burette. Suppose it takes 97·2 c. c. of the solution to neutralise the acid completely, then 2·8 c. c. must have been made up by the NH_3.

1,400. The Soda-lime process of estimation of Nitrogen though still commonly followed by agriculturalists, and though for oil-cakes, and nitrogenous manures, this method is sufficiently accurate, Kjeldahl's process should be followed in the estimation of N. in soils and other substances where it occurs in very minute proportions. In fact, the process is so easy after the apparatus is once set up, and it gives such accurate results, that there is no reason why the Soda-lime method should not be altogether replaced by it. It is adapted for liquid as well as for solid substances. The substance is first heated with strong Sulphuric acid (20 c. c. of Sulphuric acid being used for 1 gram of soil), the object being to convert all the Nitrogen in the soil into ammonium sulphate. To raise the temperature of the mixture and to make the dark liquid clear, 10 grammes of dry powdered potassium sulphate are added. The heating is continued for 2 hours after this. By this time the conversion of the nitrogen in the organic substances of the soil into ammonium sulphate is complete. Next an excess of Sodium hydrate solution is added to the digestion flask, and the flask connected with a steamer on the one hand, by means of a bent tube, and on the other, by means of another bent tube with a vertical Liebig condenser. The lower end of the condenser dips into a flask containing 20 c. c. of the standard Sulphuric acid. The boiling

of the alkaline solution in the digestion flask is done by means of a current of steam passing from the steamer through the alkaline solution (with the soil digesting in it), which ultimately gets condensed and drops into the Sulphuric acid flask carrying all the ammonia with it. After two hours' further digestion in the alkaline solution, the ammonia all comes out of the soil, and then by titrating the Sulphuric acid in the manner prescribed for the Soda-lime process, the proportion of N. in the soil, can be inferred, as before.

1,401. In conducting Nitrogen combustion in the case of highly nitrogenous substances, such as sulphate of ammonia, Guano &c., the preparation for combustion should be slightly different. A narrow tube 6″ long and closed at one end should be weighed, and about ½ gram of the substance introduced into it. This tube is inserted after the one inch of soda-lime into the combustion tube, and the rest of the soda-lime filled in as usual but very quickly.

(5) *Potassium.*—10 grams more of the soil is weighed out in a Platinum crucible, gently ignited for a few minutes just to carbonize the organic compounds. When cold, it is transferred to a beaker, 50 c. c. of strong HCl and 100 c. c. of water added, the beaker covered up, taken and left for an hour in the sand-bath. The cover is then taken off, and the beaker left in the sand-bath over-night. Next day a few drops of strong HCl should be added and the mixture kept standing for a quarter of an hour. A little water is then added, and the whole warmed. The processes of drying and boiling are repeated. The Siliceous matter will be probably slightly reddish in tinge. This is filtered out, washed, dried, ignited and weighed. Lime, Phosphates and Potash, besides other things *e.g.*, Al_2O_3, Fe_2O_3, etc., are dissolved in the filtrate and washings. These are precipitated with a slight excess of Ammonia, and left uncovered for an hour or two to get rid of the NH_3. Aluminium

hydrate is soluble in NH_4HO. Therefore the excess of NH_3 should be got rid of by leaving the beaker uncovered in the sand-bath for a little while. The abundant reddish brown jelly like precipitate contains all the Phosphorus pentoxide with Fe_2O_3, Al_2O_3 etc.; and the filtrate, the Potassium and the Lime. The precipitate on the filter-paper is thoroughly washed with hot water.

(6) *Lime.*—The filtrate and washings are boiled, and treated with Ammonium oxalate, as long as precipitate is produced. The whole is filtered and washed, till the washing shows no trace of K, tested with a platinum wire on the flame. The residue is left in the water-oven to dry, to be afterwards ignited gently and weighed as $CaCO_3$. To avoid the difficulty of burning a lime precipitate, it is best to sulphate the precipitate, *i. e.*, drive off the CO_2 by igniting the precipitate in blow-pipe flame and then add a little dilute H_2SO_4. The precipitate should be then dried on vapour-bath, ignited gently over Argand flame, then thoroughly over blow-pipe flame to get $CaSO_4$. The proportion of CaO may be inferred from that of $CaSO_4$ found out. The filtrate and washings are left uncovered in the sand-bath to dry. The dry residue is transferred to a clean porcelain bason, and gently ignited in it. The fragments adhering to the sides of the beaker are washed out into the porcelain bason when it is cool after the ignition. This is left on the steamer to dry. When dry, it is ignited again, in the same way, gently to drive off all ammonia-salts. Pure oxalic acid is then added to the bason when cool, to dissolve the bases (K and Mg), some water added, the whole dried on the steamer, and again gently ignited. The residue is dissolved in hot water, and filtered. The clear filtrate and washings are treated with HCl in slight excess, transferred to the porcelain bason, and left on the steamer to dry. It is again gently ignited. The residue is dissolved in a little water, one-third of a test-tube full of platinum tetrachloride

added, and a drop or two of HCl, and the whole left on the steamer to dry. The moist residue is washed out into a porcelain crucible with 80% alcohol. It should, of course, be washed on a filter first until the filtrate comes out colourless. The curcible is left on the steamer to dry, and afterwards in the water-oven. When cool, it is weighed.

(7) *Phosphorus-Pentoxide.*—The jelly like precipitate already mentioned is transferred into a beaker with the help of the wash-bottle. Some Nitric Acid is poured on to the filter to dissolve the adhering precipitate. The filtrate is collected in the same beaker containing the precipitate. The filter-paper is once more filled with HNO_3 when it is empty. A test-tube and a half of an acidified solution of Ammonium Molybdate is then added. The mixture is left uncovered in the sand-bath, to get concentrated. The bright yellow precipitate is collected on a filter-paper. The filtrate is treated with a little more of ammonium molybdate to see if any more yellow precipitate would form. The precipitate on the filter is washed with Ammonium Nitrate. It is then treated on the filter with just enough of dilute ammonia solution to dissolve the precipitate. A few drops of citric acid should be added to the filtrate and some $MgSO_4$ mixture. It should be then left covered up in a cold place for 12 hours. The precipitate is collected on a filter-paper, washed with NH_3-water until the filtrate is not rendered turbid with $BaCl_2$. The precipitate is dried, ignited, first gently, then before the blow-pipe, cooled, and weighed.

1,402. The determination of *available phosphoric acid and potash* has been already described (pp. 559 and 560).

1,403. The following weights etc., were actually obtained, in an analysis of a sample of soil :—

Moisture—

Watch-glasses and clip and raw soil =27·3707 grams
Watch-glasses and clip ... =24·3707 „

Watch-glasses and clip and dried soil ... ... =27·2960 grams

∴ Moisture in 3 grams ... ·0747 „

∴ In 1 gram=·0249 gram ... =2·49 %

Loss on ignition—

Crucible and soil ... ... =39 328

Crucible alone ... ... =29·328

After ignition ... ... =38·596

∴ Loss on ignition ... ... =·732

∴ In 1 gram =·0732 gram ... =7·32%

Silicates and other insoluble matter—

Crucible and insoluble residue ... =37 724

Crucible alone ... ... =29·328

∴ Insoluble residue in 10 grams... =8·396 grams

Deducting ·002 for paper ash ... =8·394 „

=83·94%

Soluble salts—

Beaker and soluble salts ... =20·3080 grams

Beaker alone ... ... =20·2465 „

Soluble salts in 10 grams ... =·0615 „

=·615%

Nitrogen—

50+47·2=97·2 c.c. of the standard solution of NaHO were required to neutralize 20 c.c. of the standard H_2SO_4 solution after titration.

∴ 2·8 c.c. of the NaHO was replaced by NH_3 from the soil.

But 1 c.c. of the alkali represents ·0031095 grams of N.

∴ 2·8 c.c. represents ·0087066 grams of N in 5 grams

=·174 %

Lime—

Crucible and Ca CO_3 ppt. and paper ash ... ... =29·433

Crucible alone ... ... =29·327

·106

Deducting ·002 for filter-paper ash, ·002

$CaCO_3$ in 10 grams ... = ·104

=1·04 %

Phosphates—

Crucible and $Mg_2P_2O_7$ and paper ash ... ... =29·392

Crucible, and paper ash ... =29·329

$Mg_2P_2O_7$ ppt. ... ... =·063

∴ In 1 gram ... ... =·0063 =·63 %

Pt Cl_4 2KCl—

Crucible and ppt. ... ... =12·7645

Crucible alone ... ... =12·6370

∴ the ppt. in 10 grams ... =·1275

∴ In 1 gram ... ... =·01275=1·28 %

$Pt\ Cl_4 \cdot 2KCl : K_2O :: 1·28 : K_2O$ in 100 of the sample.

485·5 : 94 :: 1·28 : x ∴ x, or K_2O in 100 parts of the sample =·25%

(1) *Moisture* being ... ... =2·49%

The percentage of dry matter ... =97·51

But loss on ignition ... ... =7·32%

of which moisture ... ... =2·49%

(2) ∴ *Organic matter &c.*,=4·83 in 97·51 % of dry matter.

∴ In 100 of dry matter the amount of org. matter &c. =

$$97·51 : 100 :: 4·83 : x$$

$$\therefore x = \frac{4·83 \times 100}{97·51} = 4·95\%$$

(3) *Si O_2, Silicates &c.*=83·94 in 97·51 of dry soil.

∴ In 100 of dry soil, the amount of Silicates &c.=

$$97·51 : 100 :: 83·94 : x$$

$$\therefore x = \frac{83·94 \times 100}{97·51} = 86·08\ \%$$

(4) *Ca CO_3*=1·04% in wet soil, *i.e.*, 97·51 of dry.

$$97·51 : 100 :: 1·04 : x$$

$$\therefore x = \frac{1·04 \times 100}{97·51} = 1·07\ \%$$

(5) *K_2O* =·25 % in the wet sample=

$$97·51 : 100 :: ·25 : x$$

$$\therefore x = \frac{·25 \times 100}{97·51} = ·26\ \%$$

(6) P_2O_5—$Mg_2P_2O_7$ from 100 parts of the wet sample=·63

∴ 222 : 142 :: ·63 : amount of P_2O_5 in the wet sample

$$\therefore P_2O_5 \text{ in the wet sample} = \frac{\cdot 63 \times 142}{222} = \cdot 403$$

∴ P_2O_5 in the dry soil=

97·51 : 100 :: ·403 : x $\quad \therefore x = \frac{\cdot 403 \times 100}{97\cdot 51} = \cdot 41\ \%$

(7) *Nitrogen* in the wet sample = ·174 %

∴ In the dry soil,

97·51 : 100 :: ·174 : x $\quad \therefore x = \frac{\cdot 174 \times 100}{97\cdot 51} = \cdot 178\ \%$

or calculated as NH_3.

N : NH_3 :: ·178 : NH_3 in the sample

14 : 17 :: ·178 : x $\quad \therefore x = \cdot 23\ \%$

(8) *Soluble salts*—In the wet sample ·615%

∴ In the dry soil=

97·51 : 100 :: ·615 : x $\quad \therefore x = \frac{\cdot 615 \times 100}{97\cdot 51} = \cdot 63\ \%$

1,404. The following, therefore, is the result of the analysis of the sample of soil :—

Moisture ...	...	2·49 %
Organic matter &c.*	...	4·95 „
Sand &c. ...	...	86·08 „
Calcium carbonate† ...	...	1·07 „
Potash	...	·26 „
Phosphoric anhydride	...	·41 „
Undetermined ...	...	4·474 „
		100·00

Soluble salts ... ·63 %

---

* Containing N calculated as NH_3 ... ·23 %

† Calculated as CaO ... ... ·60 „

CHAPTER CXXXV.

ANALYSIS OF BONE-MEAL.

TO analyse a sample of Bone-meal, the following method is to be adopted for determining severally the following constituents *viz.*, Moisture, Organic matter, Sand, Phosphates, Calcium Carbonate, and Ammonia or Nitrogen.

(1) *Moisture.*—3 grams of the powdered bone-meal should be weighed out in a watch-glass. This should be left in a water-oven. The loss of weight (when the weighing is found to remain constant next day), is due to moisture.

(2) *Organic matter.*—One gram of the bone-meal should be weighed out in a platinum crucible. This is ignited in low heat. When all the black particles disappear, and the residue in the crucible appears white, it is put aside in the desiccator, and when cool, weighed. The loss of weight is due to the joint loss of moisture and organic matter in one gramme of the meal, but the amount of moisture has been already determined. The remainder should be calculated as due to organic matter.

(3) *Sand.*—The residue in the crucible should then be emptied into a beaker, the crucible being also washed out into the beaker with HCl. A little more HCl is then added to the substance in the beaker; and the beaker left in the sand-bath for that day. Next day, the contents of the beaker are filtered through ordinary filter-paper; the sand on the filter-paper is washed a few times, dried in water-oven, ignited in the crucible, and weighed, when cool. The increase of weight of the crucible gives the weight of sand in a gram of bone-meal.

(4) *Phosphates.*—The filtrate and washings from the sand are then diluted to about 300 c. c.; Ammonium Hydrate is gradually added; the filtrate being stirred with a glass rod. When the precipitate settles, it is filtered through ordinary filter-paper and washed on the filter several times with ammonia water. The precipitate is then rinsed out into a beaker, the filter-paper being afterwards thoroughly washed with a little dilute HCl, the HCl being allowed to collect in the same beaker containing the precipitate. This acid redissolves the precipitate. The redissolving is necessary to free the phosphates from lime still further. It is again diluted to about 300 c. c., ammonium hydrate is again added in the same way, and the precipitate again collected in the same way on the filter-paper. It is dried in the water-oven; collected in the crucible, the filter-paper being burnt white and added to the crucible. It is ignited, put inside the desiccator, and when cool, weighed. This gives the weight of a portion of the phosphates in 1 gram of bone-meal. But as Calcium Phosphate is not quite insoluble in water, all the filtrates and washings are collected together in one beaker, and concentrated by boiling to about 150 c. c. A little acid is added to dissolve the $CaCO_3$ deposited. It is again boiled to drive away the CO_2; and when cool, Ammonium Hydrate is added gradually, and when the phosphates are deposited, they are collected in filter-paper, washed thoroughly, dried in water-oven, ignited in a crucible, the filter-paper being burnt white and added. When cool it is weighed, and the weight obtained gives the additional quantity of phosphates in the 1 gram of bone-meal.

(5) *Calcium Carbonate.*—The filtrate from the phosphates is boiled with Ammonium Oxalate. The precipitate is collected on Swedish filter-paper, dried in water-oven, gently ignited to convert the Calcium Oxalate into $CaCO_3$ instead of into CaO. The paper ash is also added. Weighed in a porcelain crucible of known weight, the

increase of weight should be calculated as being due to the weight of $CaCO_3$ in one gram of bone-meal.

(6) *Nitrogen.*—One gram of bone-meal is weighed out on a watch-glass. A strong tube 12 inches or so in length, drawn out into a closed point at one end and open at the other end is taken. It is filled with hot soda-lime (*i.e.* 2 equivalents of CaO to one of NaHO, powdered and heated on an iron pot). This is emptied out on a clean porcelain bason, except about 1 inch. A funnel is held with the left hand, the lower end being closed with the index finger, a little of the soda-lime is poured on the funnel, then the one gram of bone-meal with more than half the remaining quantity of soda-lime, which are carefully mixed together in the funnel with a Spatula. Then the finger is let go, and the contents of the funnel emptied into the tube. With the remaining soda-lime the watch-glass is cleaned out thoroughly with the help of a feather, and also the funnel. An inch of asbestos plug is then introduced; and then the Sulphuric Acid bulb containing one pipette-ful (20 c. c.) of the standard H_2SO_4 is also fixed on with a cork. This is put on the furnace. Whether the apparatus is air-tight or not is tested with a spirit lamp. The heating commencing at the bulb-end, takes about 2 hours. The quantity of H_2SO_4 neutralized by NH_3 is then ascertained.

1,406. The following figures obtained in course of an analysis of a sample of bone-meal will illustrate how the analysis is actually worked out :—

Moisture and organic matter :—

Weight of crucible + raw bone-meal = 30·336 grammes
„ crucible alone ... ... = 29·336 „

∴ Weight of raw bone-meal taken = 1 gramme

Weight of crucible + raw bone-meal = 30·33600 „
„ Crucible + ignited residue = 29·95825 „

∴ Weight of organic matter + moisture = ·37775 grammes

Weight of glass + clip + raw bone = 28·42875
„ glass + clip alone = 25·42875

∴ Weight of raw bone taken = 3 grammes
Weight of glass + clip + raw bone = 28·42875
„ „ dry bone = 28·11000

∴ Weight of *moisture* lost ... = ·31875 in 3 grammes
∴ in 1 gramme the loss is ... = ·10625 grammes (I)
∴ the weight of *organic matter* alone = ·37775 − ·10625
= ·2715 grammes (II)

Sand.—

Weight of crucible + sand ... = 29·39625
Weight of crucible alone ... = 29·33575
Difference = ·0605
Deducting weight of paper ash ... = ·0020
Weight of *sand* ... = ·0585 grammes (III)

Phosphates.—

Weight of phosphates + crucible... = 29·69450
Weight of crucible alone ... = 99·33525
Difference = ·35925
Deducting weight of paper ash ... = ·00200
Weight of phosphates ... = ·35725 grammes

Weight of crucible + 2nd precipitate of phosphates ... ... = 29·39600
Weight of crucible alone ... = 29·33525
Difference = ·06075 grammes
Deducting weight of paper ash ... = ·00200
Weight of the 2nd precipitate ... = ·05175

Total weight of the *two phosphate precipitates* ... = ·35725 + ·05875 = ·416 grammes (IV)

Calicium Carbonate.—

Weight of crucible + $CaCO_3$ precipate = 29·47 grammes
Weight of crucible alone ... = 29·33525 „

Difference = ·13475
Deducting paper ash ... = ·00200

Weight of *Calicium Carbonate* in 1 gramme ... ... = ·13275 grammes (V)

Nitrogen.—The H_2SO_4 bulb took exactly 91 c. c. of NaHO solutions. ∴ the NH_3 in 1 gramme is equivalent to 9 c. c. of alkali, which is equivalent to 9 × ·0031095 = ·0279855 grammes of N = ·03398 grammes of NH_3 = 3·398 per cent.

1,407. The *percentage composition* of the sample of bone-meal is therefore :—

(I)	Moisture	10·625
(II)	Organic matter*	27·150
(III)	Sand	5·850
(IV)	Phosphates	41·600
(V)	Calcium carbonate... ...	13·275
(VI)	Saline matter (undetermined) ...	1·500
		100·00

CHAPTER CXXXVI.

ANALYSIS OF SUPER.

IN analysing a sample of Superphosphate of Lime, the following points should be determined :—

(1) Moisture ; (2) Loss on ignition ; (3) Sand ; (4) Lime ;

* Containing 3·398 % of NH_3

(5) Soluble Phosphate or Monocalcic Phosphate ($CaH_4P_2O_8$);
(6) Insoluble Phosphate or Tricalcic Phosphate ($Ca_3P_2O_8$).

1,409. The sample taken should be well ground and bluish grey in colour.

(1) *Moisture.*—Three grams of the sample are weighed out on a watch-glass; and left in the water-oven over-night. Next morning it is covered up and secured with the cover-glass and the clip, put inside the desiccator, and when cool, weighed. It is left in the oven for another hour and treated in the same way; until the weight is found to be exactly the same as before. The loss of weight is due to the escape of moisture from the 3 grams of the Super.

(2) *Loss on Ignition.*—One gram of the sample is weighed out in a crucible of known weight, very slowly ignited on low heat, for about a quarter of an hour, until the colour of the whole mass becomes much lighter. It is then laid aside in the desiccator, and afterwards when quite cool, weighed. The loss of weight is due to the escape of moisture, organic and other readily volatile matter.

(3) *Sand.*—The residue in the crucible of the one gram just ignited is emptied into a clean beaker, every particle in the crucible being carefully washed out with Hydrochloric acid. A little more HCl is added, altogether about 50 c. c., and the beaker left uncovered in the sand-bath. When the contents of the beaker become dry, it is taken out, and strong HCl, enough to moisten the contents of the beaker, added. After a quarter of an hour, about 200 c. c. of water are added and the beaker left covered in the sand-bath over-night. The Siliceous residue in the beaker is filtered out on Swedish paper, thoroughly washed, and left over-night in the water-oven to dry. Next morning the Siliceous matter is transferred to the Platinum crucible in the usual way, the paper burnt white, the crucible ignited, left for about half an hour to cool in the desiccator, and finally weighed. The increase of weight of the crucible is due to the Siliceous matter pres-

ent in the one gram of Super, the usual allowance of ·002 grams being, of course, made for the ash of the filter-paper.

(4) *Lime.*—The filtrate and washings from the Siliceous matter in one gram of Super, are treated with a few drops of dilute Ammonium Hydrate, with constant stirring, until a permanent opalescence is just produced. A few drops of Oxalic acid are then added which for a moment clear the solution. Ammonium oxalate is then added, with constant stirring, until it ceases to produce any more precipitation. The beaker is then left covered up in the sand-bath overnight for the Calcium oxalate to collect at the bottom. Next day the Calcium oxalate precipitate is collected on a Swedish paper, and the filtrate containing all the phosphates, collected under the filter on a clean beaker. The precipitate is thoroughly washed with hot water, dried in the water-oven, and next day collected in a weighed Platinum crucible, the white ash of the filter-paper being also put into it. The crucible is ignited on very low heat, for about a quarter of an hour, to convert the CaC_2O_4 into $CaCO_3$, but not into CaO. It is cooled in the desiccator, and weighed. The increase of weight of the crucible is due to the Calcium carbonate (commonly, but inaccurately, called Lime) present in one gram of the Super, the usual allowance for the paper ash being made.

(5) *Total Phosphates.*—The filtrate and washings, from the lime precipitate, are concentrated to about 60 c. c. by boiling them in a beaker. When cool, a tea spoonful of Citric acid is added, and then to avoid diluting the contents of the beaker, a few drops of very strong Ammonium Hydrate are added, until the liquid becomes distinctly ammoniacal. Usually no precipitate follows. If a precipitate immediately follows, it would indicate the presence either of lime, iron, or alumina. The next step, *viz.*, the addition of Magnesium Sulphate solution, should be taken when the liquid is quite

cool, in the beaker. Half a test-tubeful of the "Magnesia Mixture" is added, and the beaker left covered in a cool place. Next day (*i.e.*, at least 12 hours afterwards), the crystalline precipitate in the beaker is collected on a Swedish paper, washed with rather strong Ammonia water, dried in the water-oven, collected in the usual way in a weighed crucible. The filter-paper is ignited white, and added to the precipitate. The crucible is then ignited, first on the Bunsen flame and afterwards before the Blow-pipe flame for five minutes. It is left in the desiccator to cool, and afterwards weighed. The increase of weight of the crucible is due to the Magnesium Phosphate formed in combination with the total phosphoric acid in one gram of Super, the usual weight of paper ash being allowed.

(6) $CaH_4P_2O_8$.—Five grams of the well-mixed sample of Super are weighed out on a watch-glass. Half a litre or 500 c. c., of distilled water is measured out into the wash-bottle, previously completely emptied. This water is used for the process of mixing up the Super with water. The mixing is done in the following way:—The 5 grams of Super are transferred, with the help of a feather finally, into a clean and dry mortar. The outside of the lip of the mortar is rubbed with a little grease to ensure the running out of all the water from the mortar to the Green bottle. The Super is then rubbed smooth with the pestle, a little water being added to it from the wash-bottle. Great care should be taken that none of the water in the wash-bottle might be wasted or spilt outside the mortar. The mixture is then left undisturbed for a few minutes, and the supernatant liquid is drained off carefully from the mortar along a clean and dry glass rod into a clean and dry *green* stoppered bottle. The green-bottle is used as that glass is not attacked by Phosphoric acid. As a further security against loss of water a funnel is placed on the bottle, and the water drained down on the funnel. The operation of rubbing the Super and a further quantity of water is

continued, several times, and each time, the supernatant liquid is drained off into the green-bottle, until the residue in the mortar appears quite siliceous. The mortar is then cleaned out perfectly with the remaining quantity of water in the wash-bottle, and the contents of the mortar wholly transferred into the green-bottle. The bottle is then stoppered up, and shaken every now and again for 3 hours together. It is then left to settle for over 12 hours. 100 c.c. are then filtered through into a clean measured cylinder from a Swedish paper-filter. This 100 c.c. containing the soluble phosphate in 1 gram of super, are transferred into a beaker; and the Calcium Carbonate and the Magnesium Phosphate are separated out in exactly the same way as in the case of the total lime and phosphate in one gram as already described. Only in this case the Calcium Oxalate precipitate after being thoroughly washed, is thrown away, and the filtrate treated in order to find out the Monocalcium Phosphate.

(7) $Ca_3P_2O_8$.—This is found out by difference as per calculation.

1,410. The following calculations refer to an actual analysis of a sample of super :—

(1) *Moisture.*—

Watch-glass and clip and raw super (3 grams)	=28·42875	
Watch-glass + clip + dry super ...	=27·93500	
Moisture in 3 grams ...	=·49375	
∴ Moisture in 1 gram ...	=·16458	
		= 16·46%

(2) *Loss on ignition.*—

Crucible + lid + raw super (1 grm.) ...	=30·3280	
Crucible + lid + ignited super ...	=30·0375	
	·2905	
		=29·05%

(3) *Sand.*—

Crucible + lid + sand	29·3955	
Crucible + lid alone	29·3290	
	·0665	
Less paper ash ...	·0020	
	·0645	
		=6·45%

(4) *Total Lime (Calcium Carbonate).*—

Crucible + precipitate and paper ash ...	=29·76625	
Crucible alone...	=29·32800	
	·43825	
Less paper ash ...	·00200	
	·43625	
		=43·63%

(5) *Total phosphates.*—

Crucible + $Mg_2P_2O_7$ ...	=29·545	
Crucible alone	=29·328	
$Mg_2P_2O_7$ + ash	·217	
Deduct paper ash ...	·002	
	·215	=21·5%

(6) *Precipitated phosphates in the soluble portion.*—

Crucible + $Mg_2P_2O_7$ ...	=29·520	
Crucible alone	=29·328	
	·192	
Deduct ash ...	=·002	
	·19	=19%

To calculate the *Monocalcium phosphate.*—

$$CaH_4P_2O_8 + 4NH_4HO + (NH_4)_2C_2O_4 = CaC_2O_4 + 2(NH_4)_3PO_4.$$

$2\,(NH_4)_3\,PO_4 + 2MgSO_4 = 2MgNH_4PO_4 + 2\,(NH_4)_2\,SO_4$

$2\,MgNH_4PO_4$ (on ignition) $= Mg_2P_2O_7 + 2NH_3 + H_2O$

$Mg_2P_2O_7 : CaH_4P_2O_8 :: 19\% :$ percentage of $CaH_4P_2O_8$ in the soluble portion.

i.e., 222 : 234 :: 19 : percentage of Monocalcium phosphate present.

∴ The percentage of Monocalcium phosphate in 1 gram of super $= \frac{19 \times 234}{222} = 20{\cdot}03\%$

(8) To calculate the *Tricalcium phosphate*.—

The total $Mg_2P_2O_7$ came partly from the Mono and partly from the Tricalcium phosphate.

∴ Taking 19 from 21·5, 2·5% is left as the amount from the Tricalcium phosphate.

Now, $Ca_3P_2O_8 + 3(NH_4)_2C_2O_4 = 3CaC_2O_4 + 2(NH_4)_3PO_4$.

$2\,(NH_4)_3\,PO_4 + 2\,MgSO_4 = 2NH_4MgPO_4 + 2(NH_4)_2SO_4$.

$2\,NH_4MgPO_4$ (on ignition) $= Mg_2P_2O_7 + 2NH_3 + H_2O$.

$Mg_2P_2O_7 : Ca_3P_2O_8 :: 2{\cdot}5 :$ percentage of $Ca_3P_2O_8$ in 1 gram of super.
(=222) (=310)

∴ $Ca_3P_2O_8$ present $= \frac{2{\cdot}5 \times 310}{222} = 3{\cdot}49\%$

(9) *$CaSO_4$*.—

The total $CaCO_3$ came partly from $CaH_4P_2O_8$, partly from the $Ca_3P_2O_8$ and the rest from the $CaSO_4$ present in the super, $CaSO_4$ being due to the H_2SO_4 which is added to $Ca_3P_2O_8$ in the preparation of super.

Now, $CaH_4P_2O_8 + 4NH_4\,HO + (NH_4)_2\,C_2O_4$.
$= CaC_2O_4 + 2\,(NH_4)_3\,PO_4$.

CaC_2O_4 (on ignition) $= CaCO_3 + CO$.

But $CaH_4P_2O_8 : CaCO_3$ :: amount of $CaH_4P_2O_8$ present : $CaCO_3$ which was due to the monocalcic phosphate,

i.e., 234 : 100 :: 20·03 : percentage of $CaCO_3$ due to the monocalcic phosphate.

∴ $CaCO_3$ due to the $CaH_4P_2O_8$ present $= \frac{20{\cdot}03 \times 100}{234}$
$= 8{\cdot}56\%$

Again $Ca_3P_2O_8 + 3(NH_4)_3C_2O_4 = 3CaC_2O_4 + 2(NH_4)_3\ PO_4$.

And $3CaC_2O_4$ (on ignition) $= 3CaCO_3 + 3CO$

$Ca_3P_2O_8$: $3CaCO_3$ :: percentage of $Ca_3P_2O_8$ present : $CaCO_3$ due to the Tricalcic phosphate,

i.e., 310 : 300 :: 3·49 : percentage of $CaCO_3$ coming from the Tricalcic phosphate,

$\therefore$ $CaCO_3$ due to the $Ca_3P_2O_8 = \frac{3{\cdot}49 \times 300}{310} = 3{\cdot}38\%$

$\therefore$ Taking away 8·56 + 3·38, or 11·94 from 43·63 % which is the total $CaCO_3$ obtained, we get 31·69% as being due to the $CaSO_4$

Now $CaSO_4 + (NH_4)_2\ C_2O_4 = CaC_2O_4 + (NH_4)_2\ SO_4$

CaC_2O_4 (on ignition) $= CaCO_3 + CO$

$\therefore$ $CaCO_3$: $CaSO_4$ :: 31·69 : the % of $CaSO_4$ present

$\therefore$ $CaSO_4$ present $= \frac{31{\cdot}69 \times 136}{100} = 43{\cdot}1\ \%$

(10) "*Organic matter.*"—

The total loss on ignition (*i.e.* 29·05 %) is made up partly of H_2O going off at 100°C, partly of the H_2O that $CaH_4P_2O_8$ loses on ignition and the rest is the water of crystallization of $CaSO_4$ which cannot be calculated, together with the real organic matter.

Now, $CaH_4P_2O_8$ (on ignition) $= CaP_2O_6 + 2H_2O$ ($=36$)
($=234$)

$CaH_4P_2O_8$: $2H_2O$ :: $CaH_4P_2O_8$ present : % of H_2O lost by the monocalcic phosphate present on ignition.
($=234$) ($=36$) (*i.e.* 20·03%)

$\therefore$ H_2O lost by the monocalcium phosphate on ignition

$$= \frac{20{\cdot}03 \times 36}{234} = 3{\cdot}08\%$$

But the loss of H_2O at 100°C = 16·46 %

$\therefore$ Taking away 16·46 + 3·08, or 19·54% from the total loss on ignition,

i. e., 29·05 %, we get 9·51 % as the proportion of "organic matter &c." present in the Super.

1,411. The percentage composition of the sample of superphosphate of lime analysed was :—

Moisture	= 16·46 %
"Organic matter &c."	= 9·51 „
Sand	= 6·45 „
$CaH_4P_2O_8$	= 20·03 „ (= 26·6 % of "soluble phosphate")
$Ca_3P_2O_8$	= 3·49 „
$CaSO_4$	= 43·10 „
Alkalis &c.	= ·96 „
	100·00

CHAPTER CXXXVII.

ANALYSIS OF NITRATE OF SODA AND SALTPETRE.

IN analysing a sample of Nitrate of Soda, or of Nitrate of Potash, the method employed is to find out the impurities and to estimate the amount of pure Nitrate of Soda, or Potash by difference. These impurities are generally—(1) *Moisture*, (2) *Sand and other insoluble matter*, (3) *Sodium and chloride* (4) *Sodium or Calcium sulphate*.

1,413. 35 grammes of a sample of Sodium Nitrate or Potassium Nitrate should be weighed out, and put in a clean beaker, and dissolved in about 300 c. c. of distilled water. A Swedish paper is at the same time put inside a tube and left in the water-oven to dry. Next day, the tube is stoppered and put aside to cool, weighed after an hour, and weighed again

after two or three hours, and when the weight is constant, the filter-paper is brought out of the tube, fitted on to a funnel, wetted, and the solution of the Nitrate to be analysed passed through into a clean beaker. The residue on the filter-paper is thoroughly washed, covered up with a clean piece of paper, and the funnel left in the water-oven to dry. Next day, the filter-paper is taken out with the insoluble residue on it, put inside the tube again, left in the water-oven, after an hour taken out, stoppered, and after a few hours weighed. It is weighed again after a few more hours until the weight is found to remain constant. The difference of weight gives the amount of insoluble matter in 35 grams of the Nitrate analysed. This is therefore—

(1) The *total insoluble matter, including sand.* The filter-paper is ignited white, and put in a weighed platinum crucible. The increase of weight is due to sand and other siliceous matter alone, the usual allowance being made for the filter-paper ash.

(2) The *moisture* is determined in the usual way. 3 grammes are weighed out in a watch glass, left in the water-oven, weighed next day, and weighed again, both times when cool, until the weight is constant. The loss of weight is due to the amount of moisture in the 3 grams of the sample of the Nitrate.

(3) *Sodium Chloride.*—The filtrate containing the remainder of the 35 grams, after the insoluble matter has been separated, is made exactly into half a litre or 500 c. c. Of this, should be sucked out 100 c. c. containing 7 grams of the Nitrate analysed, by means of a large pipette, and placed on a clean porcelain bason. This is treated with 2 drops of K_2CrO_4 which is used as an indicator. The standard solution of Silver Nitrate is taken in a burette. When the surface of the solution inside the burette stands exactly at 0 c. c. it is gradually poured on the Nitrate-solution by using the clip. The mixture on the bason is kept con-

tinually stirred. K_2CrO_4 gives a reddish brown precipitate with 2 $AgNO_3$, with the formation of Ag_2CrO_4. But this is not permanent, as the Cl present as NaCl as an impurity in the Nitrate-solution, is immediately attacked by $AgNo_3$, or rather Ag_2CrO_4, to form AgCl. When sufficient of the $AgNO_3$ solution has been used, all the Cl gets just used up. This is indicated by the formation of a slightly permanent reddish brown colour due to Ag_2CrO_4.

(4) *Lime* is determined in the usual way: 100 c. c. of the remainder of the Nitrate-solution is sucked up with a pipette, placed in a clean beaker, heated nearly to boiling, $(NH_4)_2C_2O_4$ and NH_4HO are added in excess until all precipitation ceases, and the liquid smells strongly ammoniacal. It is left covered up over-night in the Sand-bath, then filtered through Swedish paper, washed, dried, gently ignited, and weighed in the usual way. The weight of $CaCO_3$ determined is due to the amount of Calcium Sulphate present in 7 grams of the sample of the Nitrate (*i. e.* 100 c. c. of the solution).

(5) *Sulphur Trioxide.*—100 c. c. of the original 500 c. c. of the Nitrate-solution should be taken and made into 300 c. c. with distilled water; boiled; precipitated with Barium chloride. Nitric acid is also added to intensify the action. The precipitate is allowed to settle in sand-bath. It is next day filtered, dried, ignited and weighed in the usual way, and the amount of $BaSO_4$ determined, taken in connection with the amount of Lime previously determined, gives the amount of $CaSO_4$ present as impurity.

1,414. *The Standard Silver Nitrate-solution.*—For estimation of Chlorine (or its equivalent of NaCl) in substances analysed, it is necessary to have a standard solution of silver nitrate always ready. The Decinormal solution is in general use. It is made by dissolving 16·97 grammes of pure silver nitrate in 1000 c. c. of distilled water. The solution must be neutral. Now the molecular weight of $AgNO_3$ is 169·7, and

as the solution made contains 16·97 grammes of $AgNO_3$, it contains $\frac{1}{10}$th of the molecular weight of $AgNO_3$ per litre. 1 c.c. of this solution therefore represents $\frac{1}{10000}$ of the molecular weight of chlorine, or of NaCl, *i. e.*, ·00355 grammes of chlorine, or ·00585 grammes of NaCl.

1,415. The solution of which the Cl or NaCl has to be determined must either be neutral, or slightly alkaline with a fixed alkali, or slightly acidulated with acetic acid. The potassium chromate used for titration must be also neutral and free from chlorides.

1,416. The following calculations refer to an actual analysis of a sample of Sodium Nitrate:—

Porcelain crucible + sodium nitrate ...	... =60·65 grams
Porcelain crucible alone ...	... =25·657
	35 grams.

(1) *Moisture.*—

Watch glass + clip + nitrate of soda	... =27·3725
Watch glass + clip + dry $NaNO_3$	... =27·2245
∴ Moisture in 3 grammes	... = ·148
Moisture in 1 gram ...	=·04933=4·93 per cent.

(2) *Insoluble matter.*—

Glass tube + stopper + paper + insoluble matter	... =13·180
Tube + stopper + paper ...	... =13·832
Insoluble matter in 35 grammes	... = ·048
∴ Insoluble matter in 1 gram	=·00137=·14 per cent.

After ignition.—

Crucible + ash	... =29·3620
Crucible alone	... =29·3315
	·0305÷35
∴ Insoluble siliceous matter ...	... =·0009 (in 1 gram)
	=·09 per cent.

$BaSO_4$.—

Crucible + ppt. + paper ash ... ... =29·3650

Crucible alone... ... ... =29·3315

·0335

Less paper ash ... ... =·0020

$BaSO_4$ in 7 grammes ... ... = ·0315

∴ $BaSO_4$ in 1 gram... ... =·0045=.45 per cent.

$CaCO_3$.—

Crucible + ppt + paper ... ... = 29·3425

Crucible alone ... ... = 29·3305

·0120

Less paper ash ... ... = ·002

·01 (in 7 grams.)

∴ $CaCO_3$ from one gram ... =·00143=·14 per cent.

(3) *$CaSO_4$*.—

Now, $CaCO_3$ gives $CaSO_4$, ∴from ·14% of $CaCO_3$ we get

100 : 136 :: ·14 : x(=$CaSO_4$)

$$i.\,e.\ x = \frac{\cdot 14 \times 136}{100} = \cdot 19\%\ \text{of}\ CaSO_4$$

(4) *Na_2SO_4*.—

Again, $CaSO_4$ gives $BaSO_4$, ∴·19% of $CaSO_4$ obtained, came from

(136) (233) $\frac{\cdot 19 \times 233}{136} = \cdot 33\%$ of $BaSO_4$

But, the total $BaSO_4$=·45 per cent.

From which take away ·33 per cent. coming from the $CaSO_4$

Which leaves ·12 per cent. as coming from the Na_2SO_4

$BaSO_4$ gives Na_2SO_4, ∴·12 per cent. of $BaSO_4$ gives

$$\frac{\cdot 12 \times 142}{233} = \cdot 07\ \text{per cent of}\ Na_2SO_4$$

(5) *Na Cl*.—

76·3 c. c. of $AgNO_3$ were required for 7 grammes

∴10·9 c. c. for 1 gram.

But 1 c. c. $AgNO_3$ (standard) = ·00589 grammes of NaCl.
∴ The amount of NaCl present
= ·00585 × 10·9
= ·06376 = 6·38 per cent.

1,417. The percentage composition of the sample of Nitrate of Soda analysed is, therefore :—

(1)	Moisture	= 4·93 per cent.
* (2)	Insoluble Matter	= ·14 ,,
(3)	$CaSO_4$	= ·19 ,,
(4)	Na_2SO_4...	= ·07 ,,
(5)	NaCl	= 6·38 ,,
(6)	∴ $NaNO_3$...	= 88·29 ,,
		100·00

* Containing Sand = ·09 %.

CHAPTER CXXXVIII.

ANALYSIS OF OIL-CAKE.

FOR FODDER.—In analysing a sample of oil-cake for fodder, the proximate constituents to be determined are six in number.—(1) Moisture; (2) Ash; (3) Fibre; (4) Oil; (5) Albuminoid and (6) Soluble organic matter. In powdering oil-cake, grains, etc. preparatory to analysis, Messrs. Baird and Tatlock's Analytical Grinding Mill (price £8-15) should be used.

(1) *Moisture.*—To determine the amount of moisture

present in the sample, 3 grams of the powdered cake should be measured out on a watch glass and left in the water-oven to dry. After a few hours it is weighed again. After another hour it is weighed a third time, and when it is found to remain constant in weight since the last weighing, the difference from the original weight is calculated as being due to loss of moisture in 3 grams. At the two last weighings the usual precautions of cooling the substance inside the desiccator, covering it up with another watch-glass and fastening them together by means of the clip should be taken.

(2) *Ash* or mineral matters.—Two grammes of the cake should be weighed out in the platinum crucible, already cleaned, ignited and cooled in the desiccator. The cake is ignited on the Bunsen flame. When rendered quite white, *i. e.*, after about half an hour, it is set aside in the desiccator to cool. When cool, it is weighed, and the difference between this weight and the weight of the crucible alone is due to the ash ingredients in the 2 grammes.

(3) *Fibre*, or indigestible and insoluble organic matter.—3 grams of the sample should be weighed out into a beaker. Two scratches should be made on the side of the beaker, one at 150 c. c. and the other at 200 c. c. 150 c. c. of distilled water should be added to the cake, and the beaker placed on the wire gauze over the flame. The whole is brought to boiling heat with continual stirring to prevent burning. At this stage 50 c. c. of an H_2SO_4 solution containing 5% of pure H_2SO_4 are added to the mixture; and the boiling continued exactly for half an hour after that. The normal volume of 200 c. c. is maintained throughout by the addition of hot water at intervals during the half hour. The residue from this acid-digestion is collected over a filter on a piece of linen rag. It is washed several times with hot water while on the rag; and then when it ceases to turn litmus paper red, it is transferred to a beaker. 150 c. c. of water are added again,

and the mixture brought again to boiling heat, and at this stage 50 c. c. of a 5% KHO-solution are added. The mixture should be boiled exactly for half an hour again. It is again filtered through linen rag, washed, and transferred to a weighed crucible. The crucible is left on the steam-bath over-night and in the morning transferred to the water-oven. When perfectly dry it is weighed, the increase of weight being due to the insoluble fibrous matter contained in 3 grams. From this is subtracted, the weight of the ash which is determined by igniting the fibrous matter in the crucible, cooling it in the desiccator and weighing it again.

(4) *Oil.*—Two grams of the finely powdered cake are folded up in a piece of Swedish filter-paper, and inserted in a tube between plugs of carded cotton wool ; above the upper cotton plug is placed a loosely coiled brass spiral. A glass flask is weighed, and a quantity of Ether introduced into it, and the tube with the cake inside it is fitted on to this flask with the help of a perforated cork, while the upper end of the tube is connected by means of a bent-tube with a flask which remains plunged in cool water throughout the operation ; hot water and cold water being alternately applied under the flask with the ether. When hot water is applied, the ether evaporates, passes through the cake, and becomes condensed in the other flask. When cold water is next applied, the ether returns bringing some oil in extraction. The etherification process is repeated 10 times, when the ether returning through the end of the tube over the ether-flask is found quite free from any trace of oil. The flask is then dried on the steamer, and then put inside the water-oven, and weighed. The increase of weight is due to oil.

1,419. *Estimation of Nitrogen.*—This is done exactly in the same way as in the case of the sample of soil and of bone-meal, the analysis of which has been already described in detail.

1,420. An actual analysis worked out in the following way :—

(1) *Moisture.*—

Watch glasses + clip + oil-cake ...	= 28·42875	grammes
Watch-glasses + clip + dry oil-cake	= 28·12150	,,
∴ Moisture in 3 grammes ...	= ·30725	,,
∴ Moisture in 1 grm. ...	= ·10242	,,

(2) *Ash.*—

Crucible + cake	= 31·33525	grammes
Crucible + ash residue ...	= 29·47350	,,
∴ Loss of moisture and organic matter in 2 grammes ...	= 1·86175	,,
∴ 1 grm.	= ·93088	,,
Deducting loss of moisture ...	− ·10242	,,
Loss of organic matter ...	= ·82846	,,
∴ Weight of moisture and ash in 1 grm.	= 1 − ·82846	,,
	= ·17154	,,
Deducting loss of moisture ...	− ·10242	,,
Ash alone in 1 grm. ...	= ·06912	,,

(3) *Fibre.*—

Crucible + dry fibre ...	= 29·538	grammes
Crucible alone	− 29·328	,,
∴ Fibre + ash in 3 grms. ...	= ·210	,,
Crucible + ignited residue ...	− 29·344	,,
Crucible alone	= 29·328	,,
∴ weight of ash in 3 grms. ...	= ·016	,,
∴ weight of true fibre ...	= ·194	in 3 grms. of cake.
∴ weight of true fibre in 1 grm.	= ·06466	grams.

(4) *Oil.*—

Weight of glass flask and oil ...	= 24·838	
,, glass flask alone	= 24·601	
,, of oil in 2 grms.	= ·237	
∴ weight of oil in 1 grm. ...	= ·1185	

(5) *Soluble organic matter*, or albuminoids, mucilage and other soluble non-nitrogenous substances.—

Total organic matter as ascertained by ignition = ·82846 grms.
But of this, weights of oil and fibre = ·06466 + ·11850
= ·18316 grms.
∴ weight of soluble organic matter = ·6453 „

(6) *Albuminoids* (*Nitrogen*).—

79·3 c.c. of the standard alkali were required to neutralise 20 c. c. of the standard H_2SO_4-solution at the titration operation.

∴ An amount of NH_3 corresponding to 100-79·3.
= 20·7 c.c. of the standard NaHO solution was contained in 1 grm. of oil-cake.

But 1 c.c. of alkali represents ·0031095 grms. of N and ·0037758 of NH_3

∴ 20·7 c.c. of the alkali = 20·7 × ·0031095 grms. of N
= ·063665 grm. (N).
and 20·7 × ·0037758 grm. of NH_3
= ·07816 grammes (NH_3)
= ·40744 grammes of albuminoid.

1,421. The percentage composition of the sample of oil-cake analysed was therefore—

(1)	Moisture	= 10·242
(2)	Ash	= 6·912
(3)	Fibre	= 6·466
(4)	Oil	= 11·850
(5)	Albuminoids ...	= 40·744
(6)	Soluble organic matters...	= 23·786
	...	100·000

1,422. *Starch and sugar.*—While analysing a sample of cake for fodder, it should be noted if there is any starch or sugar, in the cake, which are indicative of adulteration. Two grammes of cake may be taken in a small (4 or 5 ounce) beaker, 100 c. c. of water added, the mixture boiled for 5 minutes, and then allowed to cool. One

portion is to be decanted off (not filtered), when quite cold, into a porcelain bason and Tincture of Iodine added drop by drop. If any blue colour is noticed while stirring, the presence of starch is to be inferred.

Another portion of the above liquid, about $\frac{1}{3}$rd of a test-tubeful is taken. To it is added one-third of its bulk of the "sugar test" and boiled for 2 minutes. If a yellow or red precipitate forms the presence of sugar is to be inferred.

1,423. *Sugar test.*—The "sugar test" consists of a solution of copper sulphate with an excess of Sodium and Potassium Tartarate (Rochelle salt) made strongly alkaline with Sodium Hydrate solution. The reaction consists in the reduction of CuO to Cu_2O (*i.e.*, from black oxide to red oxide of copper).

1,424. *Analysis of oil-cake for manure.*—If an oil-cake is used both as a fodder and manure, besides moisture, ash, fibre, oil, and albuminoids, which are found out in analysing oil-cake which is used as fodder alone, the amounts of Sand, Lime, Phosphoric anhydride and Potash, present in the ash should be determined. If, as in the case of castor-cake and *mahua*-cake, the substance is not required for fodder but for manure alone, it is unnecessary finding out the proportions of oil, fibre and albuminoids in the sample, but it is very necessary finding out the proportions of $CaCO_3$, P_2O_5, and K_2O besides N, and such foreign substances as sand and moisture.

1,425. After determining the percentage of ash in the usual way, the ash is dissolved in half a litre of distilled water; each 100 litres representing 3 grammes of cake in the example given below, 15 grams of cake being ignited for obtaining the ash for analysis.

1,426. 200 c. c. of the solution (representing 6 grammes of the cake) should then be taken. Fe_2Cl_6 is then added and NH_4HO to take down the jelly like precipitate. The precipitate is washed with ammonia water. The precipitate

is collected in a beaker, dissolved in HNO_3; ammonium molybdate is added the $Mg_2P_2O_7$ precipitate and estimated as in the case of analysis of soil.

1,427. The filtrate and washings are concentrated by boiling, and ammonium oxalate added to precipitate calcium oxalate in determining lime in the usual way.

1,428. The filtrate and washings from the last are taken to dryness in a sand-bath, ignited on a porcelain bason, and treated as in the case of soil in estimating $2KCl, PtCl_4$.

1,429. The following example shows how an analysis of a sample of oil-cake for manure is worked out:—

(1) *For moisture.*—

Watch glasses + clip + raw cake	=25·743
Watch glasses + clip	=24·743
Watch glasses + clip + dry cake	=25·6595
∴ Moisture in 1 gram ...	=·0835=8·35 %

Loss on Ignition.—

Crucible + ignited cake (1 gram)	=30·3280
Crucible alone	=29·4785
∴ Loss on ignition	=·8495
	=84·95 %

Deducting 8·35 per cent. for moisture,

(2) *Organic matter &c.*— ... ... =76·60 %

(3) *Sand &c.*—

Crucible + sand &c.	=30·390
Crucible alone	=29·327
∴ Sand &c. in 15 grams	=1·063
Deducting ·002 for paper ash	=1·061
∴ In 1 gram	·0707=7·07%

(4) Nitrogen calculated as *Ammonia*.—

Watch glass + cake	=6·7855
Watch glass alone	=6·1866
∴ The quantity taken for combustion ...	=·5989 gram

50+39½ c. c.=89½ c. c. of the NaHO solution was required to neutralize the pipette full of H_2So_4 after combustion.

$\therefore$ $100 - 89\frac{1}{2} = 10\frac{1}{2}$ c. c. of NaHO was replaced by NH_3 coming from the ·5989 grammes of the cake.

But 1 c. c. of the alkali represents ·0037716 grammes of NH_3

$\therefore$ $10\frac{1}{2}$ c. c. represents ·0396018 grammes of NH_3 in ·5989 grammes of the cake.

$\therefore$ In 1 gram of the cake, the NH_3 would be ·066 grammes = 6·61% = 34·43% of albuminoids.

(5) *$CaCO_3$.*—

Crucible + $CaCO_3$ from 200 c. c. + paper ash ... = 29·402

Crucible alone ... ... = 29·326

$\therefore$ $CaCO_3$ + paper ash ... ... = ·076

Deducting ·002 for paper ash

$CaCO_3$ in 6 grams ... ... = ·074

$\therefore$ In 1 gram ... ... = ·0123 = 1·23%

(CaO = ·69%)

(6) Crucible + $Mg_2P_2O_7$ + paper ash ... = 29·4675

Crucible alone ... ... = 29·3255

$\therefore$ $Mg_2P_2O_7$ from 6 grams ... ... = ·142

Deducting ·002 for ash ... ... = ·14

$\therefore$ $Mg_2P_2O_7$ in 1 gram ... = ·0233 = 2·33%

$Mg_2P_2O_7 : P_2O_5 :: 2·33 : P_2O_5$ in the cake.

$$\therefore P_2O_5 \text{ in the sample} = \frac{2·33 \times 142}{222} = 1·49\%$$

(7) *K_2O.*— Crucible + ppt ... ... = 26·015

Crucible alone ... ... = 25·6575

$\therefore$ 2K Cl. Pt Cl_4 in 6 grams = ·3575

$\therefore$ In 1 gram ... = ·0596 = 5·96%

$PtCl_4$ 2KCl : $K_2O :: 5·96$: amount of K_2O present.

$$\therefore \text{ amount of } K_2O \text{ present} = \frac{5·96 \times 94}{488} = 1·15\%$$

1,430. The following therefore are the results of the analysis of the sample of the oil-cake for manure :—

Moisture ... ... = 8·35 per cent.

* Organic matter &c. ... ... = 76·60 „

† Ash ... ... = $\frac{15·05}{100·00}$ „

* Containing 34·43% of N—ous matter calculated as albuminoids

† Containing—

Silicates &c.	...	...	=7·07 per cent.
CaO	...	...	=·69 ,,
P_2O_5	...	...	=1·49 ,,
K_2O	...	...	=1·15 ,,

CHAPTER CXXXIX.

ANALYSIS OF SILAGE, GRASS &c.

IN analysing leaves, hay, silage and roots, some difference has to be made in the estimation of albuminoids from the method recommended for oil-cake for fodder, though the moisture, oil, fibre and ash, are determined as in the case of oil-cakes. Leaves &c. contain nitrates, amides and amines, which have little or no feeding value. True albuminoids* should be separated from other nitrogen-compounds and the Nitrogen in these alone estimated by one of the two processes described in connection with the analysis of soils. The separation of true albuminoids is done in the following way:—

1,432. Orthophosphoric acid is put on the lid of a Platinum crucible and gently heated on a triangle over a Bunsen flame. Spurting is avoided by moving about the Bunsen flame. When it becomes quite glassy Orthophosphoric acid changes into Metaphosphoric acid. In this state it is put inside a beaker along with the Pt-lid and a little distilled water to dissolve the Metaphosphoric acid. 2 grammes of

* According to Frankland the heat-producing power of fat to that of albumen and starch, is as 100 : 47·4 :: 43·1. Fat and starch have no flesh-forming power. Albumen is therefore complete food.

silage, hay, or any other food-stuff of this class that is analysed, are put in a beaker, moistened with a warm Phenol solution (4%), and a few drops of the metaphosphoric acid solution are added. After a quarter of an hour 100 c. c. of the same phenol solution in a boiling state, are added, the mixture stirred, and then left to cool. The whole is then transferred to a filter, the washing being done with the help of a wash-bottle containing the same phenol solution in a cold state. The albuminoids getting coagulated by the phenol solution remain on the filter, while the non-albuminoid nitrogenous compounds pass off with the filtrate. The contents of the filter are then dried and the nitrogen therein estimated either by the combustion process or by Kjeldahl's method.

1,433. The following figures refer to an actual analysis of a sample of silage :—

Moisture.—

Crucible + powdered silage ... =30·860
Crucible alone ... ... =29·327

1·533 grammes taken

Crucible + dry silage ... ... =30·755
∴ Loss in 1·533 grammes ... =·105
=6·84 %

Dry silage taken ... =1·533−·105=1·428 grammes

Fibre.— Glass + stopper + silage =37·446
Glass + stopper ... ... =34·446

3 grammes taken

Wt. of porcelain crucible + dry fibre =12·0995
Wt. of porcelain crucible alone ... =10·9665

3 | 1·1330

·3776 = 37·76 %

Ash.—

Crucible + dry silage ... ... =30·7550
Crucible + ignited residue ... =29·4445

1·3105 org. matter

Crucible alone ... ... =29·3270

∴ ·1175= ash in 1·428 grams of dry silage=8·22 %

Oil.— Glass + stopper + silage ... =37·446

Glass + stopper ... ... =34·446

3 grammes taken

Flask + oil ... ... =31·708

Flask alone ... ... =31·922

$$3\overline{)\cdot086} = 2\cdot86\ \%$$
$$\cdot0286$$

Albuminoids.—Wt. of glass + stopper + silage=36·446

Glass + stopper ... =34·446

2 grammes taken

50+43·5=93·5 c. c. of standard NaHO solution taken up for neutralising 20 c. c. of standard sulphuric acid.

6·5 c. c. of alkali represents

6·5 × ·196832616 grams of albuminoids=·1279412004 gr. in 2 gr.

∴ In 1 gram=·06397 grams=6·397 %

1,434. The percentage composition of the sample of silage was therefore :—

Moisture	=6·84 %
Fibre	=37·76 „
Ash (including sand) ...	=8·22 „
Oil	=2·86 „
Albuminoids	=6·39 „
Soluble carbohydrates &c. ...	=37·93„
	100·00

CHAPTER CXL.

WATER ANALYSIS.

THE farmer should be careful about the quality of the water he uses for irrigation or drinking purposes. The presence of nitrates is helpful for vegetation, but that of nitrites and of chlorine indicates sewage contamination, and nitrites are also injurious to crops.

1,436. Distillation is the only means of getting chemically pure water. Even rain water, which is the purest of all natural waters, contains traces of chlorides, ammonia, nitrates and particles of arsenic and other solid bodies, such as bacilli, meteoric dust &c. For obtaining 8 gallons of distilled water 10 gallons of ordinary water should be used. This should be distilled from a copper still connected with a block tin worm. The first half gallon of distilled water is to be rejected and the next 8 gallons kept.

1,437. In testing the purity or adaptability of water, the following points should be noted: (1) Total Hardness; (2) Permanent Hardness; (3) Chlorine; (4) Nitrates and Nitrites; (5) Free Ammonia; (6) Albuminoid ammonia and (7) Total Residue after distillation. The points which a farmer should specially note are Chlorine, Nitrates and Nitrites.

(1) *Total hardness* represents the whole amount of lime and other salts which render water hard. Clarke's soap test is applied for determining total hardness. 50 c. c. of water are taken in a stoppered bottle of about 200 c. c. capacity. A burette is filled with the standard soap solution, and, 1 c. c. added each time and the bottle shaken. When the lather remains permanently for 5 minutes further addition of the solution should be stopped and the number of c. c. of the solution used read off. Then from the "Table of Hardness" the proportion of $CaCO_3$ in 100,000 parts of water,

determined. 1 c. c. of the soap represents ·48 parts of $CaCO_3$ in 100,000; 5 c. c., 6 parts; 10 c. c., 13·31 parts; 15 c. c., 21·19 parts, and so on, as per Table.

(2) *Permanent Hardness* indicates ihe amount of Calcic and magnesic salts in a state other than carbonate. The Calcic and magnesic carbonates are held in solution in water by the carbonic anhydride dissolved in the water. On boiling, this gas passes off and the carbonates are precipitated, while all other salts remain unaffected. A high degree of permanent hardness indicates sewage contamination, showing the presence of sulphates and chlorides, both of which might be derived from sewage matter. Moreover, it is impossible to render such water portable by boiling. In estimating permanent hardness, the soap-test is applied after boiling the water, and the result noted as "permanent hardness."

(3) *Chlorine* as chlorides also indicates sewage contamination, though sea-breeze also accounts for some of the chlorine in water. 70 c. c. of the water to be tested are placed in a beaker over a sheet of white paper and brought under a 10 c. c. burette charged with the standard solution of silver nitrate. Two drops of the solution of Potassium Chromate are then added, and the silver solution carefully run in with constant stirring, until the solution in the beaker just changes from yellow to red. This indicates that all the Chlorides have been precipitated as Silver Chloride. The red coloured Argentic Chromate will not form until all the chlorides have been removed, but whenever this is attained, the least excess of silver solution, turns the Chromate red. Each c. c. of silver solution will indicate ·00355 grammes of chlorine per litre. The Silver Nitrate and Potassium Chromate solutions must be both perfectly neutral.

(4) *Nitrates and Nitrites.*—The sample of water is treated with a hydrate and a piece of sheet-albuminium dropped in. The nitrates and nitrites are reduced to ammonia in contact with nascent hydrogen and then Nessler's test ap-

plied. As nitrates are beneficial to plant life and nitrites injurious and indicative of sewage contamination, it is important to ascertain qualitatively if there are any nitrates and nitrites in the water used for irrigation and for drinking purposes. Water containing nitrates, coming in contact with sewage, the nitrates become reduced to nitrites. For nitrites the Metaphynelene diamine hydrochloride ($C_6 H_4 \begin{pmatrix} N H_2 . HCl. \\ N H_2 . HCl. \end{pmatrix}$) test is the best. This reagent is dissolved in Sulphuric acid, and a drop of it added to water supposed to be contaminated by sewage. If yellow colour is gradually formed, the presence of nitrites is to be inferred.

For ascertaining the presence of nitrates, an equal volume of strong sulphuric acid should be added to a volume of the water tested, and then the number of drops of Indigo sulphate solution it decolourises, should be counted. The solution should be heated and it should be seen that a slight permanent colouration remains at the end.

(5) The free ammonia in water is determined by Nessler's test.

(6) *Albuminoid ammonia* is due to nitrogenous organic bodies in the water. After the free ammonia has been estimated, the residue remaining in the retort after distillation with Sodium Carbonate is heated with a strongly alkaline solution of Potassium Permanganate, sufficient being added to make up about 500 c. c. The nitrogenous matters undergo a limited oxidation and nitrogen is obtained as ammonia. Then Nessler's test is applied to the distilled liquor which is collected in portions of 50 c.c. The alkaline solution of Potassium Permanganate is prepared by dissolving 4 grammes of Potassium Permanganate and 100 grammes of Potassium hydrate in 550 c. c. of distilled water.

(7) *Total residue* is what remains behind after a sample of water has been distilled.

PART VIII.

FAMINES.

CHAPTER CXLI.

GENERAL REMARKS ON INDIAN FAMINES.

FAMINES are not to be looked upon as a novel phenomenon in India. Famines occur and have always occurred, except in the most highly civilized countries of modern Europe. In these countries trade and manufactures are in such advanced state of development, that people in them do not need to depend on their local agricultural produce only. The yield per acre in these countries is also larger and total failure of crops is prevented by the adoption of scientific methods of tillage and treatment. Severe famines are spoken of in most ancient historical works, and in India it is the paucity of ancient historical records that makes the subject of periodical failures of crops, so difficult of demonstration. Famines of long duration are however casually mentioned in many Sanskrit works, and they are spoken of as the consequence of the sins of the sovereign. The tendency of Hindus to blame the sovereign power whenever there is a famine, is, therefore, quite orthodox according to their notions. It is known, however, that even during the most prosperous and illustrious reigns, famines have occurred. In 1596, in the reign of the popular Emperor Akbar, a very

severe famine raged in India, in which people were reduced to such extremity that many kept themselves alive by devouring human flesh. In 1615-16 a similar famine occurred followed by plague which lasted several years. It is also known from authentic history that severe famines raged in the reigns of Shah Jehan and Aurangzeb. In the famine of 1770, in nine months ten million people died in Bengal. The famine of 1784 was of such bad type that four seers of wheat were sold for a rupee, and the deaths from starvation were innumerable. The most recent of all famines, *viz.*, that prevailing in some part of India or other from 1897 to 1900, has been severer than the famine of 1874-78 but neither of these two famines which are within our living memory can be compared in destructiveness of human life to the famines which prevailed more than 100 years ago.

1,439. On the other hand, it must not be supposed, that because more land has been under cultivation now than ever there was in former times, that because, on the whole, there has been steady progress in the export of food stuffs from India, that because India has had no occasion yet to look to foreign countries for means of livelihood, that because the agricultural population have been generally better off now than they ever were before, that therefore there is nothing to fear from the steady increase of population and the necessary limit there is to extension of cultivation. Already the extension of cultivation has gone on to such an extent in the populous localities, that there is not sufficient pasture-land left for the cattle. Barring occasional famines, no actual stress is felt yet regarding the food supply of the country. But in another 20 years, unless agricultural improvements keep pace with the increase of population, or plague decimates the population at a still greater rate than it has been doing, the aspect of affairs may change entirely, and India like England may have to look to foreign sources for food supply, or take to emigration on a more wholesale scale. How India stands at

present with reference to the rest of the Empire can be seen at a glance from the following table :—

	Approximate area.	Population.	Density of population per sq. mile (=640 acres).
	sqr. miles.		
1. Great Britain and European possessions ...	125,000	41,000,000	328 (less than 2 acres per individual).
2. India and other Asiatic possessions ...	1,720,000	325,000,000	189 (=over 3 acres per individual).
3. African possessions including Transvaal and Orange Free Colony ...	3,000,000	50,000,000	16⅔ (nearly 40 acres per individual).
4. American possessions ...	3,765,000	7,000,000	Nearly 2 (=320 acres per individual).
5. Australian colonies ...	3,257,000	5,170,000	about 1¼ (over 400 acres per individual).
TOTAL ...	11,867,000	428,170,000	37

1,440. Taking the area under food grains in India at 164 million acres and the produce of grain per acre per annum an 840 lbs., and the population at 350 millions, we have to the lot of each individual of the population only 393 lbs. of food grains per annum, a quantity though sufficient for the present needs, is alarmingly little, if any future expansion of population is taken into consideration. Of course, for a time the difficulty will be naturally met by the conversion of non-food areas into food-growing areas, but there is a limit to this source of expansion also.

1,441. The area covered by the British Empire is about $\frac{1}{6}$th of the area of the whole earth's surface, and the population represents a fourth of the population of the whole world. The stress of population though highest in England itself,

cannot now result in famines in that country. The following among other reasons may be ascribed for this immunity: (1) The produce per acre is much larger in England. (2) The population does not depend upon agriculture solely for subsistence as commercial and manufacturing pursuits have increased the wealth of England to such an extent that unless all means of communication by sea with foreign countries can be stopped, there is no possibility of food becoming scarce in that country. (3) The superabundance of food produce in one part or other of the vast Empire can always supply the deficient produce of England. England in fact, is not able now to produce the food she requires for her consumption. But she need not depend upon foreign countries at all: her own possessions in other parts of the world making her quite independent in this respect, though as a matter of fact England still imports a good deal of wheat from Russia, France and the United States of America. (4) Emigration to other countries is another means whereby England has maintained her position as a wealthy country notwithstanding the great stress of population. As population of India is getting alarmingly large, it is by the fourfold means noted in the case of England that India must also learn in the near future to keep herself above want in the matter of food supply :—(1) She must learn better methods of cultivation whereby the produce of land may be enhanced. (2) She must direct her attention to commerce and manufacture, whereby stress on land will be lightened. (3) She must learn to import food stuffs from those parts of the Empire where meat and corn are produced excessively cheap, as soon as famine becomes certain. (4) She must learn to send out her superfluous population voluntarily and willingly to those parts of the Empire. The stress of population, in normal years, is not yet felt in India because the allotment of 3 acres per individual of population is quite sufficient. But where cultivators readily convert their surplus food into cash in a good year, and where this

surplus food goes out into foreign countries, a bad year brings sudden distress, which is not relieved by indigenous commercial enterprise bringing food stuff in, from foreign sources, as would be the case in more civilized countries. The native grain-dealer does not trouble himself about the price of grain in Australia, Canada, or Cape Colony, when a bad year comes round, and he in common with the cultivator looks to Government for means of subsistence to be brought to his very doors. The need for emigration also is not felt yet except in special localities. But in another 20 years, the question of emigration into other part of the Empire may have to be more seriously taken up, and then India must make common cause with England and try to be recognised as an integral part of the Empire, looking upon the sparsely populated portions of the Empire as the natural field for her expansion. By assisting in the foreign wars of the Empire, and by common political sympathies with the heart of the Empire, and not by the encouragement of merely national or racial feelings, that India can hope to be recognised as an integral part of the Empire, with equal rights and privileges with England in the matter of Colonial expansion. The time will come when the right political attitude will be forced by necessity upon the intellects and consciences of the leaders of Indian thought, who can still afford to indulge in the idea that India's resources make her quite independent of such ideas of colonial expansion with which the nations of Europe are *per force* guided, compelling them to seek fresh fields and pastures new in sparsely populated regions of the globe. What is now recognized as the 'Imperial feeling' is neither a bye-word nor a mistake, but a concrete necessity, which English politicians of all schools of thought are beginning to realise, must be the solid foundation of that vast Empire to which we have the privilege to belong.

1,442. The *cause of famines* is, as is well known, the

failure of the monsoons. The tracts protected from failure from this cause are (1) the canal irrigated tracts, and (2) the regions of heavy rainfall, *viz.*, Assam and parts of Eastern Bengal, the Cis-Himalayan regions of Northern Bengal, and Eastern and Western Ghauts and Southern Burmah *i. e.* all those tracts where the normal rainfall is 70 inches per annum or more. The rest of India may be looked upon as 'precarious tracts.' Because the Rarh country suffered more than the Bagri in the famine of 1874, the Rarh was at one time considered a precarious tract, but in the famine of 1897 it was the Bagri country that suffered and not the Rarh.

CHAPTER CXLII.

THE SYSTEM OF LAND REVENUE AS AFFECTING THE QUESTION.

IT has been said that the land revenue levied by Government is so heavy, that it is indirectly a potent cause of famines. The total annual income from all sources which our Government receives is a little over 100 crores of Rupees, of which land revenue accounts for about 26 to 27 crores, or a little over one-fourth of the total income. Sir William Hunter estimates the revenue demand at 5½ per cent. of the gross produce of land. In Bengal, where most of the land is permanently settled on zamindars, the revenue demand of Government usually bears but a small proportion to the rent recovered by zemindars or the superior landlords from actual cultivators. The Government demand alone, bearing but a small proportion to the actual outturn from land, causes no appreciable hardship to the cultivator in Bengal. In comparison with the N.-W. P. and Oudh,

for instance, Bengal has to carry a very light burden in the shape of land revenue though the actual rent paid by cultivators to their landlords is higher, specially in Bihar and in Eastern Bengal, than in those up-country Provinces. The acreage of the N.-W. P. and Oudh is only two-thirds that of Bengal. Debarred by the Permanent Settlement from materially increasing the land revenue of Bengal, Government is obliged to assess a higher rate of revenue from most of the other Provinces and the burden is consequently unequal. And yet the land revenue in the N.-W. P. and Oudh seldom exceeds 10 per cent. of the gross produce of land. This is a lighter burden than what was imposed by former Governments, on land. Akbar claimed one-third of the gross produce of land as his due. From the historian Strabo we learn that at the time of Alexander's invasion of India the Raja's share of the produce was a *chouth* or fourth. Manu put the king's share variously at $\frac{1}{6}$th, $\frac{1}{8}$th and $\frac{1}{12}$th of the produce of land. The total land revenue obtained at the time of Akbar was indeed about 10 crores shorter than what is obtained by the British Government. But this may be accounted for by two causes: (1) Akbar was never able to bring to complete subjection for the purpose of assessment of land-revenue such a large territory as is owned for this purpose by the present Government. (2) There is far more land under cultivation and less jungle now than in the days of Akbar. The development of the country's resources by means of roads and canals and railways has been very great and the purchasing power of Rupee is also far less now than in the time of Akbar. The land revenue collection therefore though nominally higher is intrinsically of less value than in the time of Akbar. It should be noted, however, that in the reign of Aurangzeb the land revenue exceeded the present limit.

1,444. The present land revenue systems of India are a direct heritage from former Governments. The modifica-

tions under the British Government have been few and unimportant, the tendency having been to recognise the local customs prevailing at the time of the codification of any law regarding land. And yet tracing the main feature of the Indian land revenue system from the oldest time to the present, one cannot help confessing, the change has not been altogether to the benefit of the cultivator. The earliest inhabitants of India, known to ethnologists as Kolarians, recognised the patriarchal or family system. The proprietary rights in land rested in the family or tribal organisation by whose labours the land had been cleared or reclaimed from the jungle. Their institutions were democratic. The chiefs though they held larger and more fertile holdings, claimed no tribute or revenue as a matter of right and only accepted gifts. The democratic instinct is still ingrained among Kols and Sonthals who cultivate jungle land without waiting for anybody's permission, and who consider themselves harshly treated if they are ousted by the Zemindar afterwards. The Dravidians who followed the Kolarians extended the system of their predecessors. They permitted the proprietary rights in the land to rest with the actual cultivator. The king, however, exacted a certain share of the produce from each holding, except from those held by priests, military officers and others rendering service. The Aryans who followed the Dravidians kept up the land system of their predecessors and recognised the reclaimer of land from jungle as the true proprietor, and all landholders, except priests, kotwals and others who rendered service, paid a portion of the produce of land to the king. The Hindu system never recognised the king as the proprietor of cultivated land, but only its protector or overlord. The Mahomedan conquerors accepted the system of their predecessors as it happened to be in accord with their own laws and customs. The first important change was made by Akbar, who substituted cash payment for payment in kind. It was during

the decadence of the Moghul empire that petty chiefs, Rajas, and Jaigirdars rose into power. They had sufficient local authority to prevent collection of revenue by the officers of Government. It became necessary for the British Government in its early days to recognise these magnates and to transfer to them the claims of Government in return for an annual tribute paid by them to Government. In most cases the revenue paid by Rajas and Talukdars to Government is of this nature only. Another class of people also arose at the decadence of the Mahomedan power, *viz.*, one to whom Government farmed out the right to collect revenue, to retain a certain share of it for their trouble (afterwards known as Malikana), and to pay the balance to Goverment. This is the origin of the Zemindar class. The Permanent Settlement recognised permanently the maximum collection the British Government could make, at the latter end of the eighteenth century, in these provinces. Lord Cornwallis only carried on the existing system by collecting revenue through Zemindars. The Permanent Settlement, however, was saddled with three serious mistakes, which Government have been since trying hard to rectify without breaking its pledge with the Zemindars. (1) No survey of estates or holdings was made and the revenue was fixed for ever irrespective of the extent or the possibilities of the estate. (2) The rights of the cultivators were not safeguarded, and practically no limit was placed to the rent demands, though the revenue demand was fixed for ever. (3) In fixing the land revenue for ever, Government is hampered in the matter of taxation, Zemindars, for instance, being exempt from the payment of income-tax at the expense of their fellow subjects. When it is remembered that half the income-tax of Bengal is derived from the residents in Calcutta, it may be inferred how trade is unduly hampered by this limit of choice on the part of Government. The light burden of land revenue of about 3 per cent. of produce imposed on permanently settled estates necessitates the imposition of a

heavy burden of 10 per cent. in the case of estates not permanently settled, and thus the burden is unequal without any adequate reason as regards prosperity or otherwise of the cultivator.

1,445. The actual incidence of land-revenue per acre of cultivated *net cropped* area in the different Provinces of British India and Native States may be judged from the following figures compiled from the Agricultural Statistics for 1898-99: —

	Rs.	As.	P.
Bengal	0	12	7
Assam	1	3	4
N.-W. Provinces	2	0	2
Oudh	1	15	1
Punjab	1	2	10
Sind	2	6	0
Bombay	1	6	0
Madras	2	4	11
Berar	1	2	10
Central Provinces	0	9	4
Ajmir-Marwar	1	3	11
Upper Burmah	2	2	1
Lower Burmah	1	15	4
Coorg	1	4	11
Mysore	1	8	6
Bikanir	0	7	7
Jaipur	4	3	11
Gwalior	2	5	9
Marwar	0	15	10
Tonk	2	9	6

1,446. The above figures show that the Government demand in the shape of land revenue is very light, and it is not any more in British India than in most Native States. Though a Rupee was far more valuable in olden days than now, the land revenue in the days of the Moghul Emperors was about the same as now. In 1664 the land-revenue of India

under the Moghul empire stood at 26 crores 74 lakhs, and in 1665 at 24 crores 5 lakhs. In Aurangzeb's time the land revenue was assessed at 34 crores of Rupees. In the case of Bengal, it will be seen, that though the Government demand is only about 4 as. per bigha, the rent actually paid by the cultivating raiyat is seldom so low as 4 as., and it is often as much as Rs. 3 or even Rs. 10 per bigha, and the average rent of agricultural land in Bengal is about Re. 1 per bigha or Rs. 3 per acre. To lay the blame, when famine or distress of any kind prevails in the country, on Government, and to say the poverty of the people is due to over assessment of land revenue, is absurd. Of course, the high rent actually paid by cultivators in other than Government estates, is due to the facilities at present existing for the creation of intermediate proprietorship and tenures between the Government and the actual cultivator. But this system can be changed only at the sacrifice of the Permanent Settlement to which Government is pledged in most parts of Bengal. Besides it cannot be said Bengal suffers any more from famine than other parts of India, or that the raiyats in permanently settled estates in Bengal are worse off than the raiyats of the Central Provinces, for instance, though the former pay the average rent of Rs. 3 per acre, while the latter only 12 annas, per acre. The greater fertility and the more settled rainfall of the Gangetic plain, make our province more secure against famines, though the cultivator is burdened with larger demands in the shape of rent by their immediate landlords.

CHAPTER CXLIII.

MEASURES OF PROTECTION AND RELIEF.

LEGISLATIVE measures.—It is not impossible for Government to help the cultivator by legislative methods. (1) The exportation of new rice may be prohibited. This may have the effect of cultivators, zemindars, mahajans, and grain dealers holding large stocks of grain until the next season's prospects are certainly known. It is not difficult to distinguish between old and new rice and the prohibition can be easily enforced. (2) The export of bones and oil-seeds (not oils) may be prohibited. (3) The minimum proportion between land revenue and rent may be fixed for ever. (4) All cultivating raiyats may be compelled by law to maintain one food or fodder yielding tree per acre of land he holds, the list of such trees being published from time to time and nurseries maintained in connection with District Engineers' offices and inspection bunglows, whence planting from road, river and canal sides may also proceed systematically. (5) Each Village Union may be compelled to maintain a conservancy establishment, and allotted fields for burial of dead animals, night soil and other refuse matter, where trees yielding food and fodder may be systematically grown, and fuel and fodder sold from this miniature forest after 10 years' growth. This is a modification of Dr. Voelcker's recommendation regarding propagation of fuel and fodder reserves.

1,448. *Departmental measures.*—The agricultural Department may teach raiyats how to store grain, by having stores of superior varieties of seed at certain recognised centres for sale to raiyats. One variety of seed may yield twice as much as another variety, all other circumstances remaining

the same. The collection of seeds of prolific varieties of grains, pulses &c. may occupy the time of a special travelling officer of the Agricultural Department. The same officer may collect seeds, tubers &c. of drought-resisting and flood-resisting crops. Some varieties of rice do well in dry soils by sending their roots deep down into the soil. Some varieties, on the other hand, increase in height as the flood increases. A list of such prolific, drought-resisting, and flood-resisting, crops, may gradually be prepared by the Agricultural Department after careful enquiry and experiment; and seeds, roots and cutting of such crops may be kept for sale to raiyats in the recognised seed-distribution centres. This may also have the effect of protecting raiyats from taking inferior seeds from *mahajans* on loan on ruinous terms. A maund of paddy seed, for instance, may be valued by the *mahajan* at the sowing season when he gives it out for Rs 2. At harvest time he values the paddy at Re. 1 a maund, and takes back 2 maunds of paddy by way of principal and another maund by way of interest. The *mahajan* does not mind if the *raiyat* loses his crop. He advances him another maund of seed again to him next year, and then if he has a good crop he takes back from him $7\frac{1}{2}$ maunds, *i. e.* 3 maunds on account of previous year, $1\frac{1}{2}$ maunds on account of interest for that 3 maunds subsequent to the harvest, and 3 maunds for the 2nd year's loan. Thus in two years the *mahajan* gets back $7\frac{1}{2}$ maunds for the loan of 2 maunds of seed which he may have bought at a cheaper price than what he sells his $7\frac{1}{2}$ maunds at. It is local price at harvest time that the *mahajan* considers when securing his grain, and it is local price at seed time at which he gives it out, and if the price of seed is cheap, he sometimes does not give it out at all but holds his stock till next year, or the year after, when he gets the best bargain, selling the grain as grain and not as seed. It is in this way some *mahajans* in Bengal were found to own several lakhs of maunds of paddy in the

famine year of 1897, and they let it all out that year. The *mahajani* system has its advantages, if no better system of supply of good seed at more reasonable rates can be substituted in its place. But if an official system or a system devised with the aid of local bodies or bankers can be substituted for it one of the greatest of curses under which the Indian cultivator has lived from time immemorial, will be removed.

1,449. The Agricultural Department may also organise a system through village unions and *putwaries*, of lending out irrigation and other machinery, superior bulls, &c., on hire. Behia mills have, no doubt, been popularised without such aid, but as a matter of fact, the *raiyat* needs a helping hand, as small farmers in every other country do. The fruits of agricultural science can filter down to actual cultivators only by means of an organised agency, where the cultivators are either illiterate or very poorly educated, who are not accustomed of their own accord to make new departures. Of course, the principal lever to move the *raiyat* is education, specially agricultural education, but an expert agency working in connection with village unions, may also accomplish a great deal.

1,450. The extension of canals and railways are further measures of protection which Government has been steadily developing. Death from starvation even in localised famines was more general in times past than now, when means of communication with the interior are easier. But a greater state of progress in these directions is desirable.

1,451. *Relief works.*—The means of affording relief when famine actually breaks out are detailed in the Famine Code. One suggestion, however, will not be quite out of place in a book like this. By the end of September or middle of October it becomes quite evident, whether famine is going to take place or not. If the general outturn estimated for the whole province by the Agricultural Department, of

Bhadoi and *Aman* crops, falls short of 50 per cent., it may be assumed that there will be famine, though people may not begin to come to test or relief works till February. Relief works should be started in each *thana* where the estimated crop is 25 per cent. or less. All works organised for relief of famine should be arranged for from October to January,—the actual opening of test-works, however, being delayed as long as possible. The programme of works should include only such as are calculated to increase the produce of land directly or indirectly. It is a sorry sight to see thousands of men and women employed in raising a road 4 or 5 feet high, when their energy might have been devoted to irrigating lands on canal and river sides, and raising a food-crop, or when they might be employed more usefully in excavating canals, irrigation channels, tanks and even wells. The roads made by famine people are usually so badly made, that the next rainy season makes the fact quite patent that making of *kutcha* roads is not a suitable work for these people. Growing a crop by irrigation at the driest season of the year, from February to May, would be a splendid object-lesson to *raiyats*, which may have a permanent effect in their learning how to avoid famines for all times to come. Relief works ought to aim at giving such object-lessons to the cultivators. Earth-work in a tank or a well is as easily measured as on a road, and in the large expanse of a paddy field it would be easy getting 5,000 labourers employed under one supervising staff, if 1000 wells are excavated in it at regular distances. Each well would cost about Rs. 25, inclusive of the cost of well-rings, and the work would not take more than a week accomplishing. Each party of five can be then employed in irrigating with leather buckets, worked by bamboo levers, an acre or two of land, $\frac{1}{10}$th to $\frac{1}{5}$th of an acre being irrigated every day according as the soil is light or heavy, cultivating the land, and raising a crop from it, in three months, of maize, or millet, or *aus* paddy,

or some pulse. The crop will just come in when the famine is at its full height, from May to July. If 2,000 acres can be irrigated out of a paddy field 5,000 acres in expanse and 40,000 maunds of food grains thus raised from the tract the lesson thus taught is not likely to be forgotten very soon. In some suitable localities *dôns* may be employed and a thousand of these worked beside a canal or a stream, may serve to irrigate 4,000 acres of land, by the employment of 3,000 persons, 2,000 being employed in working the *dôns* and distributing the water, and 1000 in cultivating, sowing, weeding &c. We never hear of the energies of famine labourers being thus utilized in raising a crop at the worst time of the year, and throwing in an extra supply on the market when the food supply usually gets to the lowest ebb. Another special advantage claimed for the system of relief work here recommended is, cultivators, will be able to go and work in their own fields from June instead of diverting their attention to famine works to the great detriment of the agricultural prospects for the succeeding year. From February to May is the slack time for cultivators, and if by artificial methods a food-crop can be then raised by people in distress, the advantage will be two-fold.

1,452. *Agricultural Banks.*—These should be under Government supervision, and Government can guarantee an interest of 3 per cent. per annum and transfer to the Banks the duty of granting *takavi* loans on interest. Any *raiyat* contributing to this Bank can thus be sure of his principal and at least 3 per cent. by way of interest, and of getting back in years of local distress the whole amount of his contributions and accumulated profits, or on joint application of a number of cultivators and shareholders, of getting back the whole amount of their joint contribution. A larger amount can be lent on joint security, under certain restrictions and interest charged thereon at $6\frac{1}{4}$ per cent. As shareholder, a *raiyat* should be eligible to share in the

profits of a Bank provided his balance does not fall below Rs. 100, though he may contribute any amount down to a minimum of Rs. 10 per annum to make him eligible for sharing in the benefits in years of distress. The Banks should invest the money in securities approved by Government; but speculations of an agricultural character approved by Government should be allowed. A scheme worked on such a line will teach *raiyats* economy and it may lay the foundation of a great many agricultural improvements. If 3 per cent. of interest is guaranteed by Government and if the banks are controlled by Government, there should be no lack of shareholders and of capital. The best agency that one could think of at the present moment to whom Government might entrust the duty of organising agricultural banks in connection with post-offices, and agricultural enterprises of various sorts on improved methods, is the India Agricultural Development Company Limited, which has been recently formed.

CHAPTER CXLIV.

AGRICULTURAL EDUCATION.

WE have alluded to agricultural education as one of the principal means of overcoming famines. The means must necessarily be slow in its operation, but it is the surest means of all; and if the system of agricultural education devised is of a sufficiently practical character, the effect need not take very long in being perceived. Foundation has been laid of agricultural education in Bengal; but the arrangement that are possible to make at Sibpur, will enable Government to give agricultural education of a rather high standard, to only about a dozen individuals annually. If these men (who are mostly graduates in Science of the Calcutta

University) are judiciously employed, they can supply all the special agricultural agency needed for developing the educational and experimental works under Government. The passed men of Sibpur may be employed in charge of farms attached to the Normal Schools which should form the centres of that form of agricultural education which should be imparted in the different vernaculars of the province. The practical work of the farms can then be conducted under those conditions under which agriculturists have to work in the different parts of these Provinces. The methods or staples that may be introduced with success at Sibpur, may not answer for Hazaribagh, or for Kalimpang, or for Cuttack. Men trained in scientific principles of agriculture will be able to adopt new methods suited to the conditions and environments under which they work, and what village school-masters should be taught are not so much the principles or the theories, but concrete facts regarding improvements that are feasible in their own particular localities. At the School of Agriculture at Nagpur, village school-masters are given training in agriculture for a period of six months only (inclusive of holidays and vacation). In 6 months or one year, these men can be taught to advantage only certain new methods, and if they go back to their villages or village schools with seeds and cuttings of half a dozen new and valuable staples, one or two new implements, and with their minds stocked with various useful information regarding the manner of pickling seed, of avoiding insect and fungus pests, of avoiding the effects of drought or inundation, their training will be directly beneficial in introducing improvements in the villages in which they will be employed, by means of school-gardens. The knowledge communicated through text-books by means of object-lessons in the school-garden, is bound to spread in a real manner. The pupils will be naturally anxious, for instance, to get from their school-garden seeds of such valuable staples as the fine

aus paddy, Cabul gram, popat beans, white-linseed, bulbs of African yam, cuttings of cassava and suckers of Sansiviera trifasciata and Fourcroya gigantia. Their books on agriculture should not be devoted to teaching, on the one hand, what the pupils and their parents are already quite familiar with, nor, on the other, to attempting to stock the minds of the pupils with abstract notions of botanical physiology and abstruse facts regarding nitrogen, potash, and phosphoric acid, leaving to the pupils the hopeless task of making use of the *principles* they are taught in introducing agricultural improvements in their own way. They should be shown certain definite examples of improvement in their school-gardens, and their teaching should be thoroughly concrete. The school-masters themselves may be taught agriculture in a more systematic manner in farms attached to Normal Schools, but in village schools should be taught only certain definite facts which will enable the pupils to derive some immediate benefit from their school education. If the school-going son of a cultivator can be of help to his father in his own difficulties, the father and the son will both begin to find out that education and farming are not necessarily antagonistic to each other. If the village school-master can be of help to the raiyat in his own business, the raiyat will think more highly of his own business also, than he is accustomed to think at present. The tendency among cultivators and artizans who attain to some amount of prosperity by following their own ancestral craft, is to shun their craft, to take to money-lending, and to make clerks of their sons. The spread of literary education has been antagonistic to the advancement of arts and industries and it is very important that from the lowest stage children should have education of such a character as may enable them to pursue their ancestral occupations with greater ability and interest, instead of despising such occupations and taking to others which are considered genteel.

1,454. By the Bengal Government Resolution No 1 dated

the 1st January 1901, foundation has been also laid of such a system of education for village schools. It now remains to extend the principle to High Schools and Colleges. Nowhere else perhaps do the lower classes aim so much at imitating the higher classes, as they do in Bengal. The educated Nepali or Sonthal likes to be addressed "Babu"; he takes to shutting up his women folk in the zenana, and worshipping the gods and goddesses of the Bengali. If the educated classes of Bengal can be made to take more interest in farming, the cultivator will begin to despise his calling less, and will abandon the practice of making a clerk of his son wherever he can afford to do so. The educated classes of Bengal have begun to take a good deal of interest in agriculture, and it is worth while fostering and encouraging this taste, by recognising Agriculture as an alternative subject for High Schools and Colleges, and thus putting a stamp of respectability on an occupation which has been despised for ages as belonging to the lowest caste of all.

1,455. This, in fact, was recognised in one of the Resolutions of the Agricultural Conference held at Simla on the 6th October 1893, and the particular Resolution of this Conference here referred to has been quoted in the Bengal Government Resolution No 1 of the 1st January 1901. It runs thus: "That it is most desirable that the Universities should recognise the Science of Agriculture as an optional subject in the course for a degree".

1,456. If this resolution is given effect to by Government, it will open out a wide field of employment for students of agriculture. Under existing conditions it will be difficult even for a dozen men every year, passing out of the Sibpur agricultural classes, to find agricultural employment in Bengal. The Normal Schools can be supplied with farms and farm Superintendents and teachers of agriculture, right off, by utilising the services of men who have already passed out. What are future batches of students to do? Government

may, no doubt, employ them in various ways, but they will not be able to make much use of their special training in agriculture, except in agricultural appointments proper.

1,457. The principle already recognised for Primary and Secondary Schools, can be recognised also for High Schools and Colleges, and permission may be granted to all mofussil Schools and Colleges to teach agriculture in place of Physics or Chemistry. It is less expensive organising gardens and farms in connection with mofussil Colleges and High Schools than making an adequate arrangement for teaching Chemistry and Physics, and many Colleges and High Schools may avail themselves of the permission right off by employing passed students of the Sibpur agricultural classes, to teach Agriculture in place of Chemistry and Physics. However meagre the arrangement that may be made by a mofussil school or college for teaching Agriculture, this subject cannot possibly be worse taught than Physics or Chemistry is at present. Facts of agricultural science abound in the mofussil, and if the teacher employed has been himself taught in a practical manner, he will not need much outlay of money to impart sound knowledge of such facts and the principles under lying them, to his pupils. There cannot, in other words, be such occasion for cramming in the case of agriculture, as there is in the case of Chemistry and Physics, in the case of mofussil schools and colleges. In course of time, specimens of rocks, minerals, crops, manures, economic products, insect and fungus pests, will accumulate, if the teacher does his duty, and the subject will be always better and better taught. In the case of Chemistry and Physics, an opposite tendency is often noticed in mofussil colleges. A sort of a laboratory is fitted up at, what is regarded as, great cost, and there is unwillingness on the part of the College authorities to replace implements and chemicals as they get broken or used up. Some agricultural implements must be bought, but their working can be shown with hired bullocks,

and no great outlay is needed for this purpose. Thriftiness on the part of School and College authorities will be less detrimental to agricultural education, than it now is to the imparting of a sound knowledge of Chemistry or Physics. As a means of developing the faculties of the mind, agricultural education is far more valuable than even a sound training in any one particular branch of science. If it is contended that a preliminary knowledge of all the sciences is necessary for a systematic study of agriculture, it may be pointed out, that agriculture as a subject by itself, which can be taught in a very easy manner and also in a very difficult manner to students of various standards of education, is recognised in all advanced countries, and that what is really needed for a right understanding of agricultural science, is only the science of every day life, which intelligent farmers of Europe and America without any scientific training, find sufficient to enable them to keep abreast with the times in their own particular occupation. If a farmer has first to be a chemist, and botanist, and geologist, and zoologist, and engineer, he will never make money by farming.

1,458. In the Introduction to this book, which is virtually the inaugural lecture delivered at the Sibpur Engineering College three years ago at the opening of the Agricultural Classes, we have expressed doubt as to the usefulness of high caste Bengalis in the sphere of practical agriculture. After three years' experience we have had ample reason for modifying the opinion. The number of students seeking admission into these classes who are really interested in agriculture is steadily increasing, and the men who have passed out and employed in agricultural work are doing such excellent work, that we feel disposed to assert that English education will have as much influence in remodelling and improving the agricultural condition of the country, as it has had in other walks of native Indian life.

THE END.

APPENDIX A.

—:-o-:—

Add the following to para 205 (p. 163) :—

Sap usually contains about 4 grammes of solid in solution to every litre. The water, therefore, in which the plant food is dissolved should contain less than 4 grammes of soluble matter per litre, that endosmosis may go on faster than exosmosis. Excessive manuring with soluble manures, results in exosmosis going on faster than endosmosis, and plants getting dried and burnt up. If horse-dung and horse-urine, for instance, are heaped up round the base of a large mango or other tree, the tree will perish in a few months.

206. *Quantity.*—The proportion of moisture imbibed and transpired by a leguminous crop during the whole period of its growth has been determined by actual experiments to be about 280 times the weight of the dry matter of the crop; while in the case of cereals the proportion is about 1 : 320. But one crop differs from another, and even one variety of one crop differs from another variety (*e. g. aus* and *aman* paddies) very much in this respect. Roughly speaking 1 : 300 may be taken as the average for crops during the cold weather (which is the result of European experience) and 1 : 1000 for the hot weather crops of this country. But as hot weather crops can depend chiefly on rainfall, even in a bad year, the maximum requirement of crops of irrigation water may be put down at 300 times the dry weight of the crop. Suppose an acre of wheat including straw weighs 3 tons. The dry weight of the crop is about $2\frac{1}{2}$ tons. The maximum requirement of irrigation water for this crop is ($2\frac{1}{2} \times 300$) 750 tons of water or nearly 200,000 gallons. A *dôn* lifting 10,000 gallons of water per hour, or 80,000 gallons per day is found in practice to be able to irrigate an acre of wheat in one day; and two irrigations are found ample for the wheat crop even in the worst season. Thus the maximum quantity of irrigation water required for this crop, as theoretically determined agrees very nearly with what is actually allowed in practice. But there are extreme cases of peculiar habits of plants. The Cicer arietinum, the Panicum

muticum and some other crops are able to utilise their 280 or 320 fold amount of moisture from the nocturnal dew, while most varieties of rice are benefited by an accumulation of water at their base continuously for about 70 days. Still the value of this theoretical determination as to the maximum irrigation requirements should not be lost sight of by officers entrusted with the management of canal irrigation. Even in a bad year, if the rice crop can be given two or three irrigations, *i. e.* if 200,000 gallons of water can be made available per acre during an emergency, even this crop can be saved.

APPENDIX B.

The following addition may be made to para 749 (p. 479):—

It should be also noted, that the root development of the tapioca plant goes on far more freely when the plants are kept down to a height of 2 to 3 feet only, by occasional nipping of terminal leaf-buds.

APPENDIX C.

The following addition may be made to para 783 (p. 485):—

This ball of earth is then secured by an envelope of coir, or a piece of sacking, and the whole tied up with a piece of string. Fish manure (*i. e.* rotten fish mixed up with earth) is largely used in place of a ball of clay. Jadoo fibre may be also advantageously used along with clay or fish manure, to encourage freer growth of roots. The roots will be found protruding from the ball of earth and its enveloping materials, and then the new plant may be regarded as being ready for severing and for planting out in the field. Small fruit trees must be protected by gabions, and watering must be resorted to if the rainy season does not persist. In the Darjiling hills and in

Assam, where the *gootee* or *gul-kalam* system is largely employed in propagating the orange and the India rubber tree respectively, the rainfall is so copious, that artificial watering, while the *gooties* or *gul-kalams* are on the trees and after they are planted out, is scarcely ever found necessary.

APPENDIX D.

Add the following to para 823 (p. 516) :—

Nitrogen is principally assimilated as nitrates in combination with inorganic bases. The liability of nitrates getting lost by washing when there is a crop growing in the field, is not, therefore, great. It is in the green and unripe stages of plants that most of the N in them can be traced as nitrates. The N in very immature grass or fodder is not indicative of albuminoids, and it is therefore not advisable to use fodder plants before they flower. The descending sap which goes back into the soil by exosmosis contains Calcium Malate and other compounds which are made up of a base and organic acids. All the bases of the nitrates cannot therefore be traced with the Nitrogen in the plant specially at the later stages of its growth. For instance, for all the nitrogen which can be traced by actual analysis in a ripe crop of wheat (straw and grain), there ought to be found at least 100lbs. of bases (calculated as Ca) if all the N is to be accounted for by nitrates; but only about 20lbs. of bases (calculated as Ca) can be so found. The rest of the bases go back to the soil after performing important physiological functions and acting as vehicle of nitrates. Similarly in the case of the ripe bean crop, for the Nitrogen that is actually traced, there ought to be about 215lbs of bases (calculated as Ca), but only about 58lbs. can be traced. On the other hand, in the case of a crop that is harvested green, nearly the whole of the base equivalent of the N can be traced. For the N in a mangold crop 300lbs. of bases (calculated as Ca) are necessary to account for the presence of all the N as nitrate, and actually 275lbs. can be so traced.

ERRATA.

[The author must apologise for the numerous typographical and other errors, a list of which is given below. Owing to certain peculiar circumstances, the publication of the book had to be hurried through the press, and in many instances press-order had to be given on the first proof.]

Page	*Line*	*For*	*Read*
1	13	given	give
16	10	fluvial	fluvial,
20	35	palæozoic	mesozoic
26	7 & 24	pistolitic	pisolitic
27	19	pace	place
,,	34	new	New
28	17, 20 & 25	Caddalore	Cuddalore
42	2	Co_2	CO_2
,,	12	Berzilius	Berzelius
45	6 & 7	stoney	Stony
51	24 & 25	Co_2	CO_2
54	11	both	bath
60	6	are	is
,,	12	·1	·1 per cent.
61	17	containing	equivalent to
,,	33	Na_3HPO_4	Na_2HPO_4
,,	34	446	44lb
74	18	70lbs	70lbs. ;
,,	29	2,24,000	224,000
75	35	1 foot	2 inches
76	33	increase	increases
83	30	glasses	glass
85	20	determines	partly determines
86	6	·29″	31·97″
,,	10 & 11	12·3 37·90	12·37 7·90
92	3	Co-eficient	coefficient
93	31	$CS\overset{NH_2}{\underset{NH_2}{}}$	NH_4SCN
94	21	formed	found
114	13	over-short	over-shot
133	Lowermost S in Fig. 16 should be D		
,,	11	(S)	(D)
137	8	fraction	traction
138	8	and three	three and four
145	11	ages	edges
153	19	TINED	SIX-TINED
,,	20, after the word 'top' insert the following :— "fixed to a hole in the body of the plough (which is called Nári-nágar in the Central Provinces)		
161	28	omit the words "Sodium chloride."	
,,	35	donot	do not
166	26	water-lifts	water-lift
168	Fig 38 has been printed upside down		
169	24	containing	continuing
170	31	to	two
173	21	orinary	ordinary

Page	Line	For	Read
175	1	These pumps	The Barrakar pumps
,,	6	work	It works
183	4	Add the following words:—"But two buckets can be worked with the same windlass up and down two steel ropes, simultaneously, and a tilting arrangement somewhat resembling that in use in Stoney's Water Lift may be so placed underneath the two pulleys on the two sides of the upright post, that the buckets may get emptied in turn as each reaches the top end of its rope."	
184	13	½*d.*	1*s.* 2*d.*
191	2	adopted	adapted
192	2	hookand	hook and
197	7	Monocotytedons	Monocotyledons
,,	30	Insert F. at the end of the line	
198	9	A.	Asparagus
,,	24	Manilla	Manila
199	12	Solanæ	Solaneæ
,,	13	Salanum	Solanum
,,	22	Convolvalaceæ	Convolvulaceæ
200	3	Trichasanthes	Trichosanthes
202	14	augustifolia	augusta
203	18	halipensi	halipense
205, 206 & 207	...	(At the headings) Sileceous	Siliceous
210	8	states	state
211	5	rafipogan	rufipogon
216	19	soil	soils
218	11	is	are
223	25	steamed	stemmed
239	6	(At the heading) adops	avdps
240	21	nex tto	next to
242	21	are	is
243	14	grain	gram
244	6	1 8 0	2 8 0
,,	7	2 8 0	2 0 0
,,	13	26 0 0	26 8 0
,,	15	0 8 0	2 0 0
,,	16	36 8 0	38 0 0
246	26	6 ft.	6 inches
247	21	plouged	ploughed
248	11	feet	inches
254	32	stage	stage,
255	21	1,000	10,000
256	5	adoped	adopted
,,	31	pith	pith,
258	10	1'13	1 : 13
259	21	Pennistium	Pennisitum
261	30	Cyamopsis, psoralioides arhariá shim	Cyamopsis psoralioides (*arhariá sim*)
263	22 (Remark Column)	400 per cent.	40 per cent.
264	20 (Remark Column).	Popat arharia shim	*Popat, Arhariá sim*
265	31	ditto. manure	manures
266	15	Guiz·otia	Guizotia
267	18	haye	has

Page	*Line*	*For*	*Read*
269	28	Latni	Lutni
276	17	actuall yincreases	actually increases
278	33	18 ft. × 36 ft.	18 in. × 36 in.
284	17	omit the word "a"	
287	27	fibre	tree gum
289	26	Grinding	Ginning
291	32	weevil	weevils
294	3	kneeding	kneading
296	15	acid	acrid
296	22	(*Pittaráj*)	(*Pittaráj*, or *Rayná*)
300	33	pounds	seers
300	34	4 seers	4½ seers
303	24	these solutions	the solution
304	19	steam	stem
306	27	non recognition	non-recognition
307	29	*suun*	*sunn*
309	6	firbe	fibre
316	14	by	of
319	29	yield-good	yield good
326	35	bulbels	bulbils
330	7	Manilla	Manila
332	10	put	put the juice
333	18	of jelly	of the jelly
335	29	Manilla	Manila
340	25	thread	wire
344	33	oncc	once
346	11	plan taffected	plant affected
350	26	Islands,	Islands;
353	20	loam	loam,
353	21	kidney beans, turnips	kidney-beans, turnips,
354	24	weak	week
359	25	lime	line
362	7	omit the word "fine."	
362	14	for	far
366	27	omit the word "also"	
369	26	Conferæ	Coniferæ
370	3	Philippinerisus	Philippinensis
370	10	manural	manurial
370	27	Stonekernels	Stone-kernels
370	34	time	times
375	35	progress	progresses
380	19	all, this	all this
381	26	lightre	lighter
382	35	than	then
385	21	1·9	·19
387	32	not made	made not
388	22	also	alone
392	21	white	White
396	4	level	level?
401	21	2 feet	2½ feet
406	22	harvest in	harvesting
409	7	canes only	canes
413	3	omit the word "also"	
436	17	trnsplanting	transplanting
438	27	grows on a	grows as a
441	5	fioat	flat

Page	Line	For	Read
443	15	lan-cet	lancet
445	16	China	Chin
450	9	omit the word "they"	
450	34	he	be
453	2	the leaf can	can the leaf
455	3	case-in	casein
460	24	cracking the	cracking of the
460	26	*miling*	*milling*
466	14	then, ones	thin ones
468	13	fruit	fruits
470	33	ofen	often
471	11	bit-ter	bitter
471	23	any where	anywhere
472	23	If it	If it is
493	10	had	have
498	32 & 33	omit the word "Sale of cucurbitaceous vegetables."	
503	24	Begin a new paragraph	
504	25	Dessicated	Desiccated
505	11	spinkled	sprinkled
512	8	$Ca_2 NO_3$, $Mg_2 NO_3$	Ca 2 NO_3, Mg 2 NO_3
513	24	$Na_2 Co_3$ or Ca Co_3	$Na_2 CO_3$ or Ca CO_3
519	30	sodium	Sodium
"	31	calcium	Calcium
"	35	top dressing	top-dressing
521	13	the basis	as the basis
527	17	$CaSo_3$	$CaSO_3$
530	19	$(NH_4)_2 Co_3$	$(NH_4)_2 CO_3$
"	"	Ca So_4	Ca SO_4
"	20	$(NH_4)_2 Co_3$	$(NH_4)_2 CO_3$
"	23	Ca Co_3	Ca CO_3
"	24	Co_2	CO_2
531	5	soil and	soil, and
"	29	Ca_2NO_3	Ca2NO_3
"	35	humus	humous
537	4	Rape cake	Rape-cake
539	2	object lesson	object-lesson
540	2	fish-guano	"fish-guano"
"	15	west	wet
"	19	weight less	weight, less
547	28	themwith	them with
548	29	The raw	Steamed
554	28	mother liquor	mother-liquor
555	4	straw-ashes less	straw-ashes, less
"	12	*potatoes*	potatoes
"	23	food materials	food-materials
"	25	using an alkaline substances as	...adding an alkaline substance to the
"	27	food substance	food-substance
557	21	dessicated	desiccated
558	8	from	for
"	16	Nitrogenous	nitrogenous
559	22	Nitrogen	nitrogen
560	16	omit the words "by the	combustion process."
"	31	14	14
"	32	farm yard	farm-yard
564	20	ochry	ochrey
566	3	green—manuring	green-manuring

Page	Line	For	Read
566	9	seed grain	seed-grain
567	33	($CaCo_3$)	($CaCO_3$)
569	2, 12 & 13	well water	well-water
570	8	soils	soil
574	4 and 5	$Na2CO_3$	Na_2CO_3
584	13	are	should be
585	11	breed also	breed, also
586	3	Œstrual	œstral
,,	28	fenugreek	fenugreck
587	23	psoroiloides	psoralioides
599	16	twice	once
,,	33	21 day's	21 days'
610	13	oxallate	oxalate
612	10	bran mashes	bran-mashes
625	31	Psoroiloides	psoralioides
626	16	converted in	converted into
634	24	fenugrek	fenugreck
641	1	and	, pregnant animals and
646	29	discolours	discolour
656	6	to	to lead to
662	7,12,15	carcase	carcass
,,	13	of	up
,,	17 & 23	vertibral	vertebral
662	28	blade bones	blade-bones
663	4	cane sugar	cane-sugar
,,	28	carcase	carcass
664	3	carcase	carcass
,,	6	cutup	cut up
,,	11	views	sinews
678	9	Thysanura	Thysauneura
,,	13 & 14	plant lice, scale insects	plant-lice, scale-insects
,,	,,	Scale louse	Scale-louse
,,	36	Coccilinidæ	Coccinelidæ
680	19	Thes ethrow	These throw
681	24	hilateral	bilateral
683	33	horse and	horse,
687	19	Cocoineelidæ	Coccinelidæ
688	20	(Rhynchophorus	Rhynchophorus
689	11	(*i*) Chætocmis	(*i*) Chætocnemis
690	27	seedling'	seedlings
691	1	veget able	vegetable
695	2	ferruginous	ferrugineous
695	26	devided	divided
696	13	screceus	sereceus
689	last line	Bromelii,	Bromelii
700	15	locutidæ	locustidæ
702	10	stationery	stationary
705	27	Dessicated	Desiccated
,,	28	cagebirds and game birds	Cage-birds and game-birds
707	26	end	and
710	3	chalcididæ	Chalcididæ
711	12	images	imagoes
,,	13	up on	up, on
,,	19	ants, &c.	ants, &c., they become epidemic in character
712	1	cellula	cellular

Page	*Line*	*For*	*Read*
712	26	tiger beetles	tiger-beetles
715	2 & 15	Cut Worms	Cut-Worms
716	9	Heliothes	Heliothis
719	26	minute	minutes
722	12	Gardinialucida	Gardinia lucida
726	5	1892 93	1892—93
727	19	Coccinellidæ	coccinelidæ
,,	33	Erioceruspela	Eriocerus pela
728	7	attack	and E 28-punctata attack
,,	19	Melonthini	Melolonthini
729	26	Jowar	Juar
730	27	nigrosigna	nigrosigma
731	2	add the words " and dodeca stigma "	
737	26	carcases	carcasses
740	15	food substances	food-substances
744	18	ate	are
,,	22	*streptocoeci*	*streptococci*
,,	23	tetra-coccus	tetra-cocci
751	20, 22, 23 & 24	dessication	desiccation
752	6	dessicated	desiccated
762	3	*Root nodules*	*Root-nodules*
763	13, 17, 24 & 33	Noble	Nobbe
774	31	stops	stopped
,,	,,	vaccinates	vaccinated
774	32	believes	believed
,,	33	can	could
776	8	viclent	virulent
786	24	aspergilius	aspergillus
787	8	ot	of
791	14	nce	once
794	10	Aspergillius	Aspergillus
806	6	mushrooms	mushroom
807	20	chemist in	chemist, in
808	8	chemist	chemist.
810	25	water oven	water-oven
817	1	digestion flask	digestion-flask
,,	11	Nitrogen combustion	Nitrogen-combustion
,,	23	taken	taken to
820	25	after titration	at the titration
833	11	Tricalcium	Tri calcium
835	18	*sodium and chloride*	Sodium chloride
,,	,,	*or*	and
838	14	25·657	25·65 ,,
839	22	But,	But
840	20	Albuminoid	Albuminoid matter
846	2	added	added,
,,	,,	precipitate	precipitated
,,	22	"=76·60 %, should go higher up	
,,	34	H_2So_4	H_2SO_4
856	21	an	at

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